A SILVICULTURAL APPROACH TO MULTIPLE USE MANAGEMENT OF SPOTTED GUM FORESTS ON THE NEW SOUTH WALES SOUTH COAST

by

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All the work enclosed herein is my own unless acknowledged otherwise.

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ABSTRACT

An increase in the demand for use of the forest resource to obtain an increasing range of benefits has led to the development of a formal multiple use theory. The implementation of this concept in resource management has resulted in a wide acceptance of dominant use zoning practices.

The spotted gum forests of the N.S.W. South Coast are considered in the light of these changing demands and their subsequent management problems. The approach to silvicultural management within a multiple use framework is examined, and the conclusion is reached that the forester must be flexible in the approach to management. This flexibility needs to reflect a knowledge of and sensitive response to the complex nature of vegetative pattern and variation within the irregular mixed species eucalypt forest.

The silvicultural implications of this approach are considered in the light of anticipated future long term multiple use management of these South Coast forests.

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CHAPTER I

INTRODUCTION

The aim of this essay is to develop an approach to silviculture which is most compatible with the nature of the New South Wales south coast spotted gum (*Eucalyptus maculata*, Hook) forests and their range of uses. A brief description of the spotted gum forests is given in this chapter, together with an account of the main uses of the forests, and the policies of the New South Wales Forestry Commission which bear on those uses.

In developing the most appropriate silvicultural approach to multiple use management of the spotted gum forests, it is necessary to consider a number of steps culminating in specific silvicultural recommendations for the forests. These steps involve an examination of what is meant by multiple use and multiple use management; what is involved in making a silvicultural decision; what factors will influence that decision; what information is required to give full consideration to all the factors bearing on the silvicultural decision; and finally, how all these aspects of forest management and inventory can be used to determine that approach to silviculture which will provide the required range of benefits from multiple use management.

1.1 The need to review silvicultural practice in the spotted gum forests.

The need for a review of silvicultural practices for the spotted gum forests is based on two factors ; (i) attitudes to standards of management have tended to lag significantly behind changing public attitudes toward the values and uses of the forests, and (ii) present forest management policies may not fully recognise the potential to provide increased public benefits through intensified management.

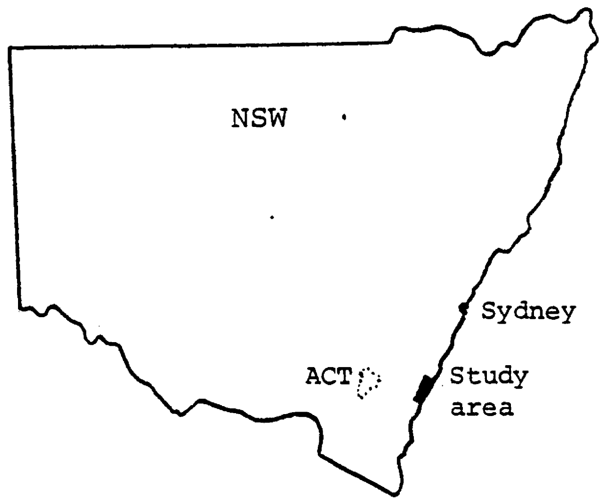
While it is recognised that new attitudes to forest management are continually being developed, the question might be asked; "are attitudes to silviculture continually being developed ?". This essay proposes that changes in policies and attitudes toward forest management need to be complemented by changes in management practice, including a more flexible approach to silviculture. It will be shown that the application of past silvicultural practices to new management situations may result in a decline in the value of the forest for a number of its wood and non-wood values.

1.2 General background to the South Coast spotted gum forests.

This essay will focus on the spotted gum forests of the NSW South Coast, from Batemans Bay north to Ulladulla. Figure 1 illustrates the location of the study area in relation to NSW generally.

Figure 1

Location of study area



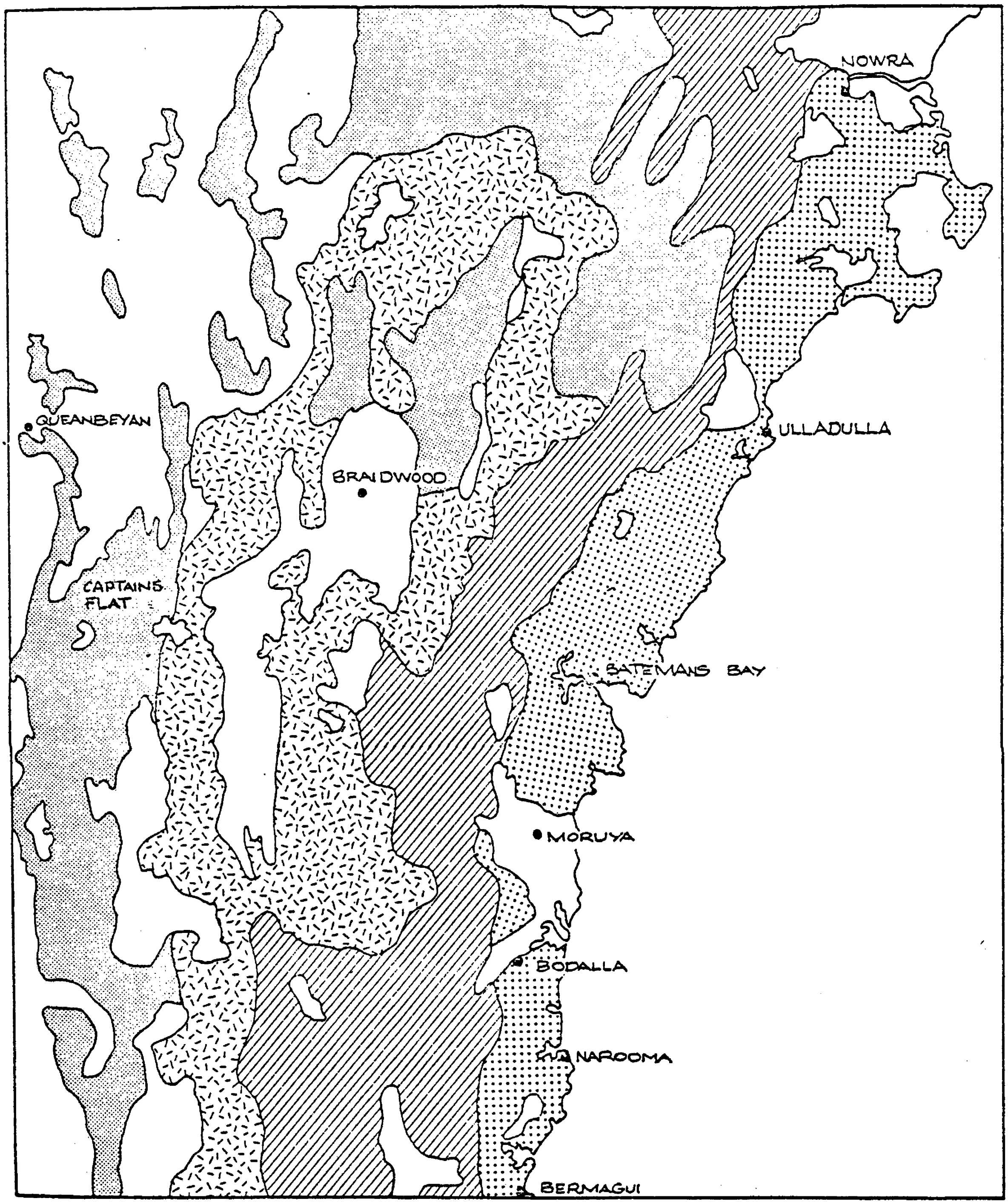
Background information on these forests will be examined in terms of the characteristics of the dominant species, spotted gum, and then in terms of the patterns of association of spotted gum with other eucalypt species, which form the characteristic irregular mixed species eucalypt forest.

1.2.1 Spotted gum as a tree species.

Spotted gum (Eucalyptus maculata, Hook) is a eucalypt species of wide coastal distribution along the Australian east coast. It grows along an 80-160 km wide coastal zone from Bundaberg, Queensland, south to East Gippsland, Victoria (Larsen, 1965). The species is characterised by its habit of growing in a complex mosaic pattern of association with other eucalypt species, but it may occur as pure stands on the better, moister sites within its range. Figure 2 shows the distribution of spotted gum forests on the NSW South Coast. Note the restricted coastal distribution of spotted gum forest in relation to other forest types.

Figure 2

Forest types on the South Coast of NSW*.



Key:

Spotted gum forest

Mixed coastal hardwoods

High altitude forest

Tableland woodland

*Source: Evans (1978)

Spotted gum grows on a wide variety of soil types under a range of climatic conditions. It reaches its best development, in terms of dominance and abundance, in the study area. Spotted gum grows in association with a number of tree species in this area including grey ironbark (Eucalyptus paniculata), yellow stringybark (E. muellerana), blackbutt (E. pilularis), Sydney blue gum (E. saligna), red mahogany (E. pellita) and bangalay (E. botryoides).

1.2.2 Spotted gum forest types.

A number of distinct forest types containing various proportions of spotted gum may be recognised, some of which are shown in Figure 3. This diagram illustrates the mosaic of broad forest types on Kioloa State Forest. However, a much more complex pattern could be demonstrated if each of the broad forest types were to be subdivided into a number of smaller but still readily defineable vegetation communities.

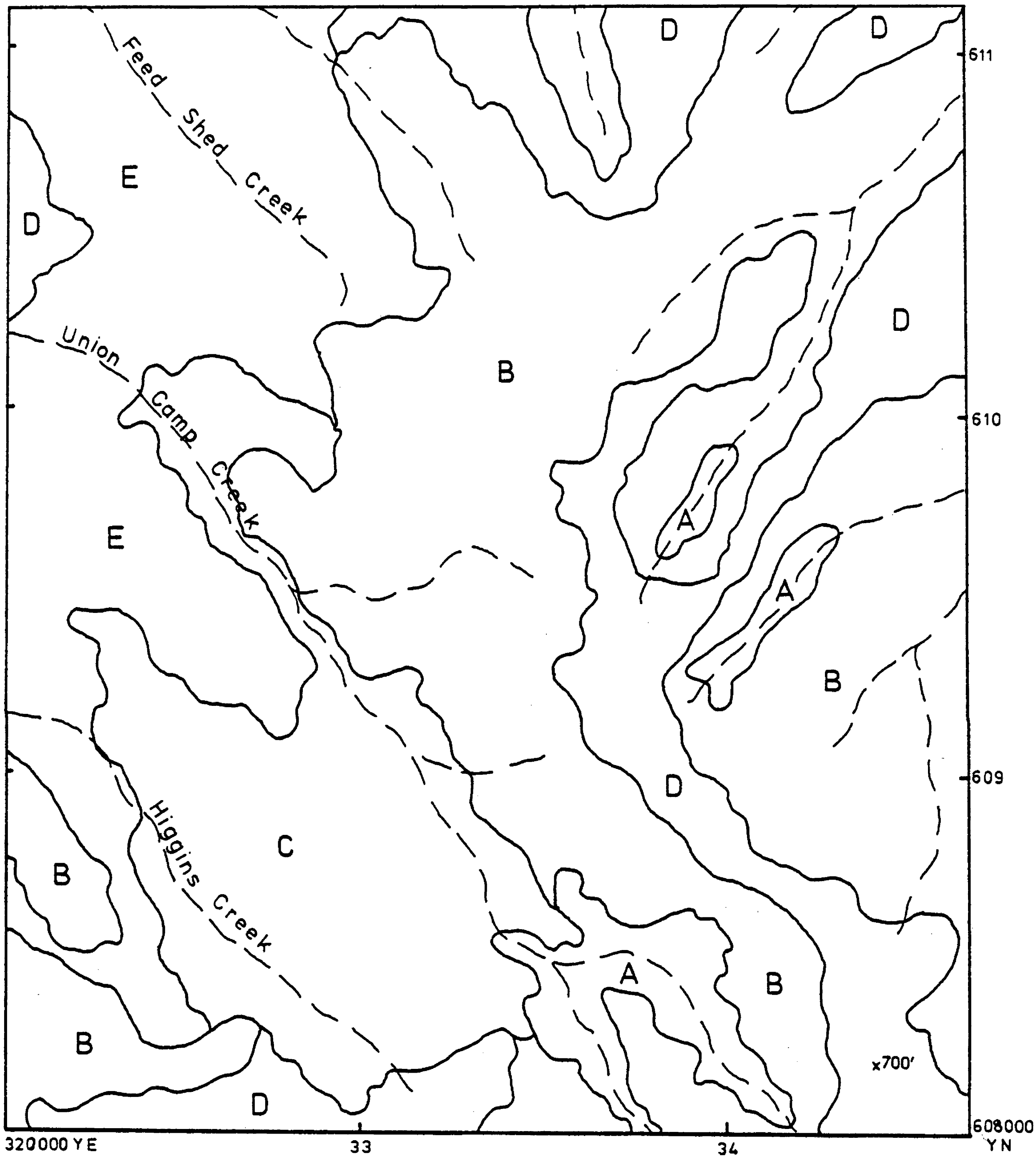
The ecology of the South Coast spotted gum forests has been examined by Furrer (1971) in terms of five (ecological) forest types recognised by the NSW Forestry Commission. These types are described in Baur (1965) as follows:

1. Spotted gum type

This type recognises a broad range of stands in which spotted gum dominates the stand. Furrer (1971) recognises two sub-types. The first one being the pure or near-pure type in which spotted gum is almost the only eucalypt tree species in the stand, and may be found most often on the

Figure 3

Forest type map - Kioloa State Forest*



A. Rainforest - non-spotted gum type.

B. Spotted gum dominant - high site quality.

C. Blackbutt dominant - low site quality.

D. Spotted gum dominant - low site quality.

E. Mixed coastal hardwoods dominant.

*Source: NSW Forestry Commission, Kioloa Group Plan 1960.

Plate A

Pure spotted gum forest type, Kioloa S.F.

Undergrowth reduced due to recent burn.

higher quality sites frequently with a mid-slope position.

The second sub-type encompasses a wide range of stands where associate species grow as minor components of the stand. Often these minor species occur in other forest types (to be discussed) but fail to reach sufficient representation in the stand to be recognised as a separate type. See Plate A.

2. Spotted gum - grey ironbark type

This type is commonly associated with the drier ridges with shallow soils, merging at midslope with the stands of the higher site quality spotted gum just discussed. In this part of the South Coast, the grey ironbark also occurs with blackbutt, yellow and white stringybark (*E. globoidea*) and bloodwood (*E. gummifera*).

3. Spotted gum - Sydney blue gum type

This is a wet sclerophyll type frequently associated with gullies. Sydney blue gum may dominate the stand in small areas but spotted gum is the wide spread dominant species. Sydney blue gum may be interspersed with bangalay and the two are known to hybridise in this area. Other associate species within this type include blackbutt, woollybutt (*E. longifolia*), turpentine (*Syncarpia glomulifera*) and red mahogany (*E. pellita*). See Plate B.

4. Spotted gum - blackbutt

The occurrence of this type on the South Coast appears to be an expression of a particularly complex relationship between species and site factors. Normally this type occurs where the site is marginal to blackbutt.

Plate B

Spotted gum - Sydney blue gum type in moist gully association in Kioloa S.F.

For example, spotted gum - blackbutt sites may be of high site quality for blackbutt, but the physical soil properties may restrict its relative competitive ability within the mixed stand. On Kioloa S.F. and Benandra S.F. some mixed species sites with blackbutt are fairly moist and of high site quality yet spotted gum often dominates over blackbutt. Other associates of this type may include bangalay, Sydney blue gum and red bloodwood. See Plate C.

5. Spotted gum - yellow stringybark

This is a wet sclerophyll type found on good sites with a south-easterly aspect along the western margin of the spotted gum type distribution. This type is considered a gradational type between the coastal spotted gum and the escarpment messmate - brown barrel (E. obliqua - E. fastigata and associates) types. Other species associated with spotted gum include mountain grey gum (E. cypellocarpa), woollybutt and stringybarks.

These spotted gum forest types have a discontinous distribution with the non-spotted gum forest types on the South Coast. The complex mosaic of the "mixed coastal hardwoods" distribution in association with the spotted gum types is evident in Figure 2. Evans (1978) has listed the species occurring in these mixed hardwood forests as silvertop ash (E. sieberi), stringybarks (E. globoidea, E. eugenioides and E. agglomerata), peppermints (E. piperita, E. dives and E. radiata), grey box (E. bosistoana), scribbly gum (E. haemastoma) and smooth-barked apple (Angophora costata).

Plate C

Spotted gum - blackbutt forest type
on Kioloa S.F.

These characteristic mosaic patterns lend diversity to the forest in terms of its value as a recreation environment. The rapid changes from wet sclerophyll spotted gum types with a mesic shrub understorey to drier spotted gum and non-spotted gum types over a distance of a kilometre or less greatly enhance the aesthetic character of this forest. Also the natural bark features and bole form of the more important species, spotted gum, blue gum and blackbutt, lend additional visual quality to these coastal forests.

1.3 A background to the use of the spotted gum forests.

Apart from the particular combination of tree quality and species within these forests, their location with respect to centres of population also have a marked bearing on their use. The extraction of wood products was well under way in the Batemans Bay area by the early 1840s (Duggin and Saunders, 1978). The timber industry developed initially with shipbuilding and gold mining, and then with the expansion of the railways. Sawn timber markets in Sydney, and later Wollongong, were readily accessible to mills cutting in the area, and today these markets still provide important centres of demand for sawn timber.

At present timber production is an important economic activity in the Batemans Bay area and a wide range of wood products are cut from the forests. For example, a pole preservation plant is operating near the town and this provides an outlet for high quality trees in the smaller log size range. Also, the stable demand for mining and heavy industrial timber is a feature of the supply of forest products from this area. A number of small sawmills depend on the supply of indigenous sawlogs from the coastal lowland forests, although steeper coastal forests are currently being cut to alleviate a shortage of sawlogs in the coastal spotted gum forests.

The location of these forests in relation to population centres is not only important for wood production but it is also a source of a more pressing demand. That is, the demand for recreation opportunities and a natural environment for holiday resort developments.

A number of small resort settlements depend on the forests to provide a natural backdrop to their access routes and the settlements themselves. These include the coastal villages of Bawley Point, Kioloa, Durras and North Durras, and the inland villages of Nelligen, East Lynne and Termeil. The location of Murramarang National Park, on the coast and completely surrounded by Kioloa and Benandra State Forests, also contributes to the demand for recreation opportunities within these coastal State Forests.

The demand for itinerant recreation opportunities is rapidly increasing in this area and the forest roads which link the Princes Highway with coastal recreation sites are having to bear increasing pressure both in terms of traffic and the critical (often urban-based) viewer. The location of these forests in relation to centres providing regular visitors such as Canberra, Nowra, Wollongong and Batemans Bay is significant, but their location in relation to a major Sydney - Melbourne highway attracts additional demand from itinerant visitors.

The pressing nature of this demand lies in the fact that it is increasing faster than the demand for wood products, and to the inhabitants of the tourist centres from Ulladulla to Batemans Bay, the forests bordering the coastal resorts must appear as an extremely valuable tourist resource.

1.4 NSW Forestry Commission policy on forest use.

The policy of the NSW Forestry Commission on the use of these forests has been broadly outlined in its publication Indigenous Forest Policy (NSW For. Comm., 1976). Section 5.4.2 of that publication specifically refers to coastal zone forests. A summary of that section, as it applies to the NSW South Coast, follows:

- ° Forests should be managed as part of a supply zone with long term production concentrated within areas of good terrain and accessibility.
- ° Such a supply zone may be surrounded by forests on steeper terrain which may be managed less intensively (i.e. for periodic yield).
- ° Coastal forests should be managed to perpetuate the species distributions, while some manipulation of species proportions within mixed stands may be appropriate.
- ° Accessible forests of the coastal plain should be managed for wood production and recreation.
- ° Management should aim to maximise sawlog production in the next 30 years, consistent with sustained yield concepts.

- Regeneration management should aim at sufficient stocking to provide adequate forest cover. Natural regeneration should be used but where necessary this may be supplemented by artificial techniques such as jiffy pot planting to obtain a full stocking of the fastest growing commercial species suitable to the site.

- In the long term, yield from these forests should be adjusted from the present levels which are determined by commitments to industry to levels determined by sustained yield estimates.

This policy of forest use contains certain implications for the South Coast forests.

Firstly, those forests, which have formed the basis of the Kioloa Management Group, will continue to produce sawlogs in the next 30 years. Also, due to the good terrain and accessibility it may be assumed they will continue to produce wood products, provided forestry is to be maintained as the preferred land use.

Secondly, recreation may be considered a forest management objective.

Thirdly, the coastal forests are to be managed as irregular mixed species forests with a minimum of investment in silvicultural treatment. Regeneration should be sufficient to provide adequate forest cover and treatment should largely aim to provide this.

These implications, and others, have been discussed by Florence (1977a). The major constraints imposed on wood producing activities through the acceptance of multiple use management (as implied by the acceptance of recreation as an objective of management) would appear to be alleviated by the use of relatively conservative logging practices. However, little explicit recognition has been given to the actual constraints on silviculture and the methods of considering them in the silvicultural decision.

The policy on coastal zone forest is based, therefore, largely on the assumption that future demand for all forest benefits (both wood products and other forest values) will be met by a low investment, low impact management approach. However, the objectives of management will not automatically be achieved in all cases unless some consideration is given to flexibility in the silvicultural approach. The approach to forest management needs to go much further than a consideration of cutting sawlogs with minimum environmental impact if the value of the forest for the provision of multiple benefits is to be maintained. The necessary approach to management has been summarised by Florence (1977a) as:

"Where the forester is sensitive to the ecological characteristics of his species, and all the variations in site factors, stand structure and growing stock condition within his forest, it should be possible to maintain or even enhance the attractiveness, diversity and dynamic status of the forest within the (policy) guidelines provided. Where the forester is not strongly motivated to meet such a challenge, the forest could well decline in terms of both future production and potential in other roles."

CHAPTER 11

MULTIPLE USE OF FOREST RESOURCES

In this section the concept of multiple use will be examined in terms of its historical development, the pressures influencing that development, and the implications of applying that concept to forest resource management.

2.1 Multiple use is simply the utilisation of a resource for a number of purposes. Multiple use of resources has been practised for centuries. The forestry profession has implemented the concept since the earliest days of organised forestry in Europe.

Multiple use of forest resources has been defined as

> "the use of a given area for several different purposes such as watershed protection, timber production and recreation. Since some uses are incompatible under certain circumstances and since maximum yields from all uses are physical and biological impossibilities, a decision has to be reached as to which uses will be given priority. Total net benefits to the community can often be increased, if not maximised through some combination of two or more uses on the ground, but there are also situations where a single use may be superior. In effect this means determining the use, or combination of uses, to which the various zones of a forest are suitable in the light of the natural environment and of social and economic considerations."
> (FORWOOD, 1974, p.9)

Recently the concept of multiple use has been formalised into an economic-based theory. Two independent pressures appear to have resulted in a formal multiple use theory. Firstly, the development of computer-based economics has resulted in the ability of analysts to map economic efficiency through techniques such as cost benefit analysis, linear programming, system analysis, input-output analysis and econometric modelling. Economic techniques have been applied to resource utilisation and have shown that the benefit to mankind can be increased simply by changing combinations of resource use.

Secondly, the pressure on natural resources has increased to the stage where formal decisions must be made as to the priorities of use and combinations of uses of natural resources, such as forests, rivers, wildlife habitat, wilderness areas and recreational areas. These resources are similar in that they are "common" public resources and not subject to the economic influences of the market place. In resolving the conflicting demands on natural resources the decision-maker has found the multiple use concept useful (Moulds, 1971 and Groome, 1971).

The development of a detailed, logical theory of multiple use has assisted the decision-maker to understand what previously had been an assumed fact of life, namely that under certain circumstances a combination of uses will yield more human benefit than a single use. The result of the recent evolution of a multiple use theory has primarily been the wide acceptance of its precepts. This has brought a new era of multi-disciplinary thinking to resource management. The manifestation of this thinking in Australian forest management will be examined.

2.2 A survey of literature on concepts and applications of multiple use solutions to resource use conflicts.

The recent evolution of a multiple use approach to resource use had its seed in the global environmental consciousness of the 1960s emanating from the USA. Grose (1974) suggests that this global consciousness is attaching a "marked importance to forests as natural environment. Forests are being looked to as important components of total human environment". Thus, as demands for wood products increase so do demands for the non-wood uses of the forest environment. The professional identification of forest use conflicts in the Australasian region resulted in professional conferences in the early 1970s being addressed to these conflicts. (IFA, 1971 ; IFA, 1974).

The embryonic development of multiple use theory reflected its inability to be applied as a definitive decision-making tool. Early authors (Dana, 1943; McArdle, 1953; Gregory, 1955; Harris, 1960; Zivnuska, 1961; McGrath, 1962; and Muhlenberg, 1964) recognised the need to consider non-wood values as part of the forest output. Quantifying the value of these non-wood products has proved difficult thus inhibiting the development of definitive criteria for resource management decisions.

2.2.1 Analytical Techniques

The application of economic techniques to problems of multiple use in Australia was restricted initially to easily quantifiable products. Such applications concentrated on developing multiple use criteria for product outputs that were valued through conventional pricing mechanisms. Thus Sinden (1964) applied economic techniques to the single use of forests for wood production based on market-determined timber prices. Lucas and Sinden (1970) applied a criterion of annual financial income per acre to determine an optimum combination of livestock and timber production. This example of livestock and timber production was further developed by Kingma and Sinden (1971) to present a production possibility frontier and an optimal solution based on current market prices. Grimes (1974) indicates a similar analysis of pasture production and timber production is being undertaken in spotted gum forest in Queensland. Reilly (1974) compares derived social benefits of forestry and agriculture on the N.S.W. South Coast measured by market values. Ferguson (1972) shows how input-output analysis can be used to measure the full economic benefits to a region of the development of a wood-chip project. The development of this analytic technique is in its infancy but its potential is being recognised (BAE, 1977).

Some attempts have been made to quantify non-wood values in Australia. Sinden (1967) suggests that multiple use decisions can best be based on analytical criteria derived from a valuation of costs and benefits not explicitly valued in the market place. Grayson (1972) points out the limitations of placing dollar values on non-wood benefits.

Techniques other than direct valuation have been applied. Thomson (1970) examines an indirect valuation through allocation of growing-costs. Opie and Thompson (1977) consider the allocation of costs associated with the constraints imposed on harvesting so as to favour non-wood values. Ferguson (1971) indicates the usefulness of the social surplus concept in estimating social benefit. He points out that an estimate of the demand function is required. Ferguson and Greig (1973) estimate a recreation demand function based on the cost of participating in the recreation experience as a price indicator.

Ashcroft (1973) surveyed aesthetic preferences of users of an exotic forest. An analysis of the production regime required to fulfil these preferences indicated that a combination of uses yielded higher measurable benefits than the single use. Sinden (1973) examines a number of valuation methods involving ranking of choice, scaling, willingness-to-pay in time, willingness-to-pay in cost and travel distance to different recreational environments. Sinden (1974a and 1974b) considers these ordinal measures of value in terms of the multiple use decision and derives certain circumstances where $-values are not necessarily needed.

Ferguson (1974) states that the analysis of the value for the net social benefit of a decision "is not a panacea for decision-making ... The strength and utility of the analytical approach to land use planning lies in the fact that it forces an explicit examination and attempt at measurement for each form of land-use in relation to welfare". (Ferguson, 1974, p. 12)

In estimating the net social benefit of alternative timber production regimes, Ferguson and Reilly (1975) indicated how such estimates can be used to assist multiple use decisions.

Ferguson (1975) in outlining future directions for research into the practice of multiple use planning, hints at the usefulness of further developments in techniques. Such techniques include linear programming and goal programming. Paine (1966) and Dargavel and Ferguson (1975) examine the application of techniques in the Victorian situation. They suggest that economics, and cost benefit analysis in particular, have a role in assisting the decision-making process. Gibson (1971) cites an example of applying linear programming to a timber production/recreation output situation. It is notable that this example depends on the delineation of mutually exclusive management area units, i.e. dominant use.

These developments in the analytical basis of multiple use decision-making have failed to provide the panacea of eliminating the value judgements from the final decision. These judgements must reflect an intuitive estimate of the net social benefit of various uses which in turn are reflected in an intuitive estimate of the demand for different uses. The participation of the public in the multiple use decision-making process not only guide the decision-makers in making the judgements but also this participation recognises the need for balance to be seen to be achieved in the final decision as to the combination of uses of an area.

The management goal of maximising net social benefit from a combination of uses over every acre of forest is thus viewed as impractical. Lucas and Sinden (1970) note that the U.S. Multiple Use Act sets the criterion of "the combination of uses which best meet the needs of the people, which is not necessarily the combination of uses that will give the greatest dollar return or greatest unit output".

2.2.2 Dominant Use Approach

Subsequently managers have accepted what might be called a "second best" solution. The second best solution has arisen because the management ideal of complete information and uniformity of resource does not exist. The nature of the forest, its history of use, and knowledge of its biological behaviour all restrict the potential to maximise net social benefit from the use of forest resources. The practical problems of continuously measuring production possibilities, of managing multiple uses, and of maintaining the resource in a healthy state have also resulted in a second best management approach.

It is becoming increasingly accepted that a priority or dominant use management approach is the best compromise. Greig (1974) examines the formal process for planning multiple use of forests. Steele (1971) indicates that land has, in the past, been set aside for a primary purpose under legislation. He suggests every opportunity should be taken to increase secondary uses within a dominant use framework.

2.2.3 Implementation

The function of setting policy for multiple use management is best served by setting priorities of use over specified land areas. Thus policy formulation is simplified and community needs can be more readily represented. The multiple use of forests is therefore implemented at the management level. Management procedures need to reflect the policy of dominant use such as timber production, catchment protection or recreation. Secondary uses can thus be catered for where they are compatible and not inimical to the primary use.

The Indigenous Forest Policy of NSW (NSW For.Comm. 1976) accepts, as a state-wide primary objective, the production of timber to satisfy demand for wood products. In comparison the national indigenous forest policy of New Zealand (NZFS, 1977) accepts as a primary objective the perpetuation of indigenous forests under State management.

Both policies accept that indigenous forests can fulfil a wide range of desirable public uses. In the case of the NSW Government the primary objective is translated into a function of determining the areas required to meet demand for wood products. Secondary uses are thus ascribed to residual areas or to areas where secondary uses are not inimical to wood production. The NSW forest policy and its implications for the South Coast Forests have been examined in Chapter 1, but it should be noted here that the policy fails to define a specific point at which a multiple use decision must be made.

In comparison the NZ forest policy defines the primary land use over every hectare of State Forest as water and soil conservation. All other forest uses are subordinate to this. In contrast to the NSW policy the NZ policy, through its primary objective, seeks to set a level of biological output rather than supply a level of industrial demand.

It is notable that the implementation of multiple use procedures in resolving resource use conflicts is reported only in decision-making authorities' policy statements. The two policy statements mentioned above bear this out and the two Western Australian Forests Department publications (W.A. Forests Department 1977a and 1977b) further substantiate this. Batini (1977) points out the importance of public involvement in the development of management plans from the land use priorities as set out in the W.A. policy statement. It is again significant that in the W.A. multiple use example (W.A. Forests Department 1977b) management priorities were set down for each hectare of forest and within each management priority area (MPA) compatible secondary uses were planned.

This approach to the implementation of multiple use concepts appears to be the most common and widespread not just within Australia but also overseas. It may be because this approach is far from the ideal and heavily reliant on the value judgements of decision-makers to resolve apparent land use conflicts that little formal comment on its development appears in the literature to date. Cutler (1978) highlighted the role of the administrator and legislator in the decision-making process and urged the greater involvement of research in the process. This relects the inadequacy of analytical tools in measuring the benefits of decisions and hence the need to call on the public to set the criteria by which decisions can be made.

In general then "the combination of uses of forest resources which best meet the needs of the people" is not being determined analytically but informally through a decision-making process which gives cognisance to both wood values, traditionally represented by industry, and non-wood values currently represented by public conservation interests. The importance of public involvement has been mentioned several times.

The following section appraises the techniques available in assisting an intuitive estimate of the net social benefit of various non-wood uses and how these estimates might be used in balanced decision-making.

2.3 Non-wood values and forest management practices

Non-wood values of forest resources include water yield, recreational environment, landscape, wildlife habitat, vegetation conservation and scientific reference. In some instances, where timber supply requisites are already adequately met from other areas, these non-wood values can be given priority. In other cases they are of such importance in themselves that management of the timber resource gives greater priority to non-wood values (this is quite often the case for forests high in catchment protection or recreation value). In yet more cases the use of the forest for non-wood purposes is incidental to timber production.

The case in which certain parts of forests are free from production commitment deserves little attention here since a multiple use decision is seldom required. Certain areas of forest periodically fall into this category. More often than not such areas result from the removal of all merchantable timber from forest areas which are low in productivity. This leaves an impoverished cutover forest of little economic attraction for timber utilisation, and conflicting demands for non-wood values infrequently arise after this point due to the absence of forest operations.

Hamilton (1977), however, records the decline in demand for wood products from the Red Gum forests of the Murray River, NSW. A change in management objectives from the previous management plan has reduced the importance of timber production among the many values of the Riverine forest resource. This is one case where areas within a managed forest have been freed from production and are thus able to meet other needs.

Increasing pressure from recreational use, however, can cause conflicts between the use and protection of the forest even in the absence of timber production. Bankes and Gray (1977) describe the recreational pressures on a forest resource close to the urban population of Adelaide. Conflicts arising from this pressure have necessitated changes in management of the multitude of recreational uses and other non-wood values. Edgerley (1977) reports on a similar trend in the exotic forests close to Canberra.

Modification of forest management practices to give precedence to non-wood values is relatively uncommon in NSW State Forests. Chapter 1 outlined the policy constraints on management goals in State Forests. It has been suggested that where the nature of the resource imparts a higher priority of use than timber production the land is taken out of the hands of the timber manager and placed under the control of another authority bound by law to give priority of management to non-wood values (Steele, 1971). In NSW, for example, certain areas of forest are vested in the control of Catchment Authorities and the National Parks and Wildlife Service for this reason.

Phillis (1975) points out, however, that in some instances these non-wood values become dominant in State Forests. The NSW Forest Policy (NSW For. Comm., 1976) accepts that timber production, although a dominant forest use, need not dominate over every hectare of the forest. "Thus the role of forests in protecting water catchment will influence such (management) matters as harvesting technique, coupe size and road construction and maintenance" (NSW For. Comm., 1976, p.25).

One aspect of these management practices is the silvicultural regime applied to the forest. Florence (1977b) points out the importance of the relationship between the silvicultural decision and the primary and secondary uses of that resource. He suggests that in the marginal situation the silvicultural decision may be critical to the compatibility of various potential uses.

2.4 Demand for non-wood values

Determining the demand for non-wood values is crucial to the adequate provision of opportunities for non-wood uses of forests. The distinction must be made here between "demand" and "consumption levels". Often these terms are used interchangably without confusion. Strictly, however, "consumption levels" measure the amount of use of a resource regardless of any factors affecting that level. Whereas "demand" measures the level of use in relation to the cost of use as well as the change in consumption level over time.

Most studies recognise the level of consumption as the demand, but Ferguson and Greig (1973) and Greig (1974b) develop true demand functions in relation to the cost of recreation.* These studies show that price is not the only variable involved in determining the demand for recreation. Other variables include perceptions of resource and recreation activity, and subjective preferences.

Management of forests for recreation uses requires data on the intensity, type and timing of recreational use at specific recreation sites (Greig, 1974c). Methods used in collecting these data include axle counters, interviews, questionnaires, self-registration and car registration identification.

Earlier studies measuring consumption levels such as those referred to by McMichael (1971) provide data on growth trends in demand which assist planning for the development of facilities and long term management.

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*A measure of true demand (i.e. in relation to price) can be used to indicate the net social benefit of recreational use of the forest by measuring the consumer surplus defined by the demand function. See Ferguson and Greig (1973).

In some State Forests the level of recreational demand has required that certain areas be managed primarily for this use. While timber production is not often abnegated it may be curtailed to minimise impact on the recreational environment. Thus the Victorian examples of Creswick Forest (FORWOOD, 1974, p.60,) Sherbrooke Forest Park (Greig, 1974c), Mt. Macedon Forest Park (Ferguson and Grieg 1973) and Gembrook State Forest (Kennedy and Lodge, 1976) show areas where recreational use dominates other uses.

Landscape values have assumed great importance in forest management under both dominant and incidental recreational use (Van Pelt, 1977). Sinden and Smith (1975) examine landscape preferences in an analytical framework. This study highlights the difficulty of measuring community requirements for landscape resources. It also suggests that exotic forest landscapes may be as valuable for recreation as indigenous forest landscapes. Speight (1977a), Lennon and Forge (1975) and Weir and Smith (1974) indicate procedures of landscape management that would be implemented where recreational values are considered in sufficient demand to require their application.

The type of recreational experience sought has led to questions on the provision of various types of resources. The question of wilderness experience has recently appeared in public discussion (Cremer, 1977a and 1977b; Brabin, 1977 and Feller, 1978). The major conflict arising here is the apparent magnitude and distribution of benefits of wilderness use and the disproportionate demand on land resources from such use. The discussion on this subject highlights the dilemma of conflicting land use based on a paucity of basic data. This conflict will only be resolved after research has established some measure of the demand for wilderness.

The demand for water yield from forests has not been quantified, yet in certain circumstances water and soil conservation values dominate all other forest values.

Activities such as harvesting, roading and burning significantly alter the water quality and quantity on managed forest land (Langford and O'Shaughnessy, 1976 and 1977). Large scale clearfelling is the most dramatic impact on the forest environment but even the effects of this management approach can be ameliorated by certain management techniques. The reservation of riparian strips, for example, from logging operations significantly diminishes changes in water values. In most cases, other than where forested catchments supply domestic water (such as Enoggera State Forest, QLD. FORWOOD, 1974), a policy of minimising effects on water values has been adopted (e.g.: NSW For. Comm., 1976). In the Enoggera State Forest example and the Western Australian case (W.A. For. Dept., 1977a and 1977b), water values impinge on forest management and substantial modifications in management practices have become necessary.

Thus in most situations the demand for water values in State Forests is not measured directly but implied as the present value of water yield on the particular site. In other words minimising the degradation of water values is a widely accepted multiple use goal.

The demand for conservation values is difficult to measure. McMichael (1971) and Attiwill (1975) suggest a minimum level can be considered as the area needed to provide a sample of all vegetation and habitat types. The optimum level of reservation, however, must take account of the distribution, size and number of reserves required to maintain genetic diversity in reserved populations. The demand for wildlife and plant conservation values within State Forests should also be considered in the light of opportunities for conservation within other land tenures including national parks, catchment areas and private land.

A complex relationship exists not only between wildlife population and habitat, but also between forest management techniques and wildlife populations. An obvious example of this is the artificial increase in feeding habitat due to the edge effect of certain forest operations. Where an increase in browse vegetation is provided by clearfelling or heavy thinning operations, the length of the edge or interface between the coupe and natural habitat will often determine the number of animals that have access to the browse (Cremer, 1969; Horne, 1975; and McCann, 1975).

The main contribution of forest management to wildlife conservation is the maintenance of natural habitat. Most authors (Steele, 1971; Frith, 1973; McMichael, 1971; Tyndale-Briscoe and Calaby 1975) recognise the contribution of areas primarily managed for timber production to the survival of wildlife populations. Extensive forest management techniques favour wildlife, and the greater the diversity in the forest structure, age and pattern the greater is the value of the forest to wildlife. Heislers (1974) suggests that wildlife values need to be given priority where fragile environments harbour restricted or endangered fauna.

In general then the demand for non-wood values is assessed in a variety of ways from strict economic analysis to intuitive "guesstimates". Most multiple use decisions are made at the resource level and non-wood needs are evaluated in terms of the resource, its physical and biological attributes, its location in respect of the source of demand and the current pressures on its use for all purposes.

2.5 Zoning for multiple use management

The task of matching estimated demands for various uses to the limited forest resource is initially a problem of zoning.

Various landscapes, soils, parent material and vegetation types present different opportunities for use and respond in different ways to such uses. Thus the highly dissected sandstone country carrying low dry sclerophyll forest in the Morton National Park west of Nowra, NSW has an intrinsically lower timber production potential than the tall coastal forests on Ordovician sediments south of Nowra (Austin and Sheaffe, 1976). These two forest types provide distinctive wildlife habitat and differing recreational potential. This difference in land suitability has been recognised in the difference in the legal status ascribed to the National Park and State Forest.

Zoning the forest on the basis of its biophysical features is the first step not only in management but also in the allocation of land use priorities.

In the past forest management practices were restricted to single use (timber production) management. Single use, non-integrated timber inventories and forest type maps provided sufficient information to conduct forest harvesting operations. With the development of the requirement for simultaneously managing multiple uses and increasing forest productivity, integrated ecological information is now essential. Basic ecological data can be provided by an integrated biophysical land inventory and suitability classification.

A highly developed land classification system is used in Canada to allocate land resources to various primary uses such as forestry, agriculture, recreation, wildlife and water yields (Lacate, 1969). The bio-physical land classification method has been summarised as "classifying land based on distinctive patterns of relief, geology, geomorphology, landforms, characteristic vegetation and climatic factors" (Rennick, 1976, p.251). The ecological basis of this land classification system is described as the integration of biological and physical features and processes and is thus an ecosystem classification (Hills, 1976). This classification system not only provides a resource-orientated base for decision making but also a basis for resource management. The ecological classification, for example, provides information for timber management through interpretations on windthrow hazard, susceptibility to brush revegetation, potential for natural regeneration, limits to regeneration and recommended tree planting species as well as interpretations on the environmental effects of timber harvesting (Walmsey, 1976).

The biophysical approach to land classification has developed with the aid of computers. Gibson (1976) summarises an Australian approach to land use planning using computer models on the NSW South Coast, and Batini (1978) examines a similar application to the catchment of the Murray River, Western Australia. Ecological zones produced through this approach provide a sound information base for the application of ecology to forest management.

The application of land use planning to the NSW South Coast has been reported by Austin and Cocks (1978). The extension of this technique to silvicultural planning, through forest inventory procedures incorporating ecological classification, will be examined further in this essay. However, the discussion will now turn to a consideration of the silvicultural decision with particular reference to the spotted gum forests where possible.

CHAPTER III

THE SILVICULTURAL DECISION

Silviculture - "the growing and tending of trees as a branch of forestry" (Fowler and Fowler, 1963) - represents the imposition of certain treatments on the natural forest to fulfil human requirements of that forest. In terms of the ecosystem concept silviculture is the artificial guidance of forest development to provide both wood and non-wood products. Nowhere is this guidance more fully expressed than in forest plantation management. In this case natural forest development is so completely modified that monocultural practices can be equated with agricultural cropping.

Carrying the agricultural analogy further, improved pasture management can be compared to enrichment silviculture, and range management with indigenous forest silviculture based on natural regeneration.

The appropriate system of forest culture must provide for the harvesting, regeneration and maintenance of desired forest species, and an appropriate stand structure. This is the aim of silviculture. It is the aim of a forest policy to set the objectives of wood supply and make adequate provision for non-wood benefits. The determination of a forest policy and the objectives of management will in turn place constraints on the silvicultural decision.

3.1 A discussion of the principles of silvicultural management of the forest ecosystem.

Management of a biological system such as a forest involves the application of treatments based primarily on a firm understanding of the structure, pattern and processes of the forest ecosystem. Silvicultural practice can also be viewed in a broader perspective. Harvesting, for example, can be regarded as that phase of silvicultural treatment where saleable wood is removed. Non-commercial wood removals may also be practised as a silvicultural treatment. Roading systems, compartment demarcation and logging practice are often designed in the light of silvicultural considerations.

Therefore, the choice of the silvicultural method depends on a number of considerations which can be summarised as biological, economic, environmental, product supply and technical efficiency.

Biological considerations such as species composition, succession, competition, regeneration and condition of growing stock determine the range of silvicultural treatments appropriate to the stand. The other considerations serve, more often, as constraints on the ultimate choice of silvicultural method, than as determinants of the range of possible choices.

D M Smith (1962) outlines the purpose of silviculture as improving on nature to increase the rate at which value is added to wood products. Any modifications to natural forest processes normally focus on the control of species composition, stand density, restocking and the age class distribution of the growing stock. This in turn depends on a knowledge of the natural processes of succession and competition within the forest stand. Thus the even-aged stands of the southern ashes, (Eucalyptus regnans and E. delegatensis) formed by the occurrence of wildfire, may be perpetuated readily by techniques imitating this natural process. Uneven-aged stands of more tolerant species may result from near climax forest development, that is, a stand left undisturbed may develop into a forest of varying aged trees with a 'normal' distribution of tree sizes. The deliberate management of an uneven-aged stand of tolerant species may imitate the natural removal of trees as they reach senescence, although to maintain stand productivity, this is normally done before such trees decline in vigour and approach senescence.

The following discussion relates to the biological factors to be considered in the silvicultural decision, examples are taken from South Coast forests where available. The aim of this discussion is to highlight the ecological characteristics of particular eucalypt forests and so show how an understanding of these characteristics can influence the silvicultural decision.

3.1.1 Species composition

The natural occurrence of various species in a mixed stand is the expression of a number of factors including edaphic, climatic, and historical factors as well as the influence of other organisms. However, the present distribution of a given species may not reflect the optimum range for that species if, for example, its distribution is restricted by fire, flood, disease or interference by man.

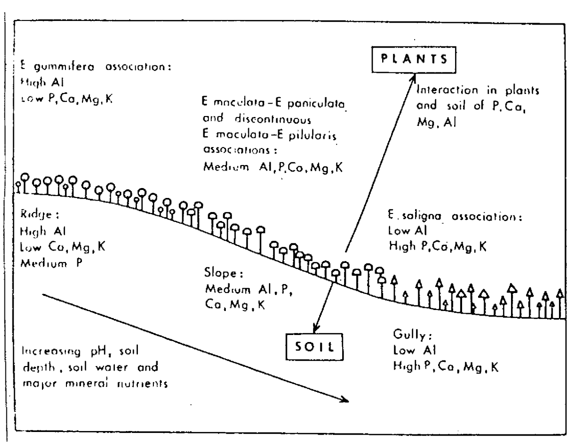
Within their natural ranges, variation in edaphic factors, including both soil physical and nutrient properties, may play an important role in determining the occurrence and associates of eucalypt species (Florence, 1969). During early growth phases the particular physiological and morphological characteristics of a species may confer competitive advantages on that species under certain environmental conditions. Awang (1977), for example, compared basic physiological characteristics of six east coast eucalypts during seedling development. The minor differences between species' competitive ability in nutrient uptake and evapotranspiration control points to the extremely sensitive nature of species pattern and its relationship with the physical environment. Lamb and Florence (1973), in examining the distribution of narrow-leaved peppermint and brown barrel in wet sclerophyll forests near Canberra, indicate the importance of soil physical properties especially soil moisture content.

Brown barrel has a narrow environmental tolerance of moisture stress and thus is less prevalent on shallow, exposed soils. However, on marginal soils the two species may form a mosaic reflecting again the sensitive response of species growth to environmental conditions.

Differential adaptation of species to small variations in nutrient supply may also contribute to species patterns. For example, studies on the ecology and nutrient processes of South Coast forests have been reported by McColl (1966), McColl and Humphreys (1967), McColl (1969) and McCutchan (1978). The soil-plant relationships of South Coast forests can be summarised using the diagram below.

FIGURE 4

Idealised diagram of some soil-plant relationships in Eucalyptus associations in Benandra State Forest NSW. Total Phosphorus (P) and exchangeable cations (Ca, Mg, K & Al) are indicated for soil. *



* Source: McColl (1969)

Figure 4 illustrates the changes in soil physical and chemical properties due to slope on Benandra State Forest. The Eucalyptus gummifera association (including Angophora intermedia, E. globoidea, E. pilularis, E. piperita and E. sieberi) is most commonly associated with shallow, stony soils low in fertility and soil moisture, and is characteristic of the ridge tops. The spotted gum - ironbark associations (E. maculata, E. paniculata, E. globoidea, E. muellerana, E. pilularis, and E. piperita) dominate the midslope soil types which are characterised by moderate fertility and a soil moisture regime which is only occasionally limiting to plant growth. The E. saligna wet sclerophyll association (including E. botryoides, rainforest species and mesophytic understorey) occupies the moist, deeper soils associated with watercourses and gullies.

Although the generalised nature of Figure 4 reflects typical soil formation processes for the one parent material, it does not accurately represent the causal factors for individual species' distributions. McCutchan (1978) compared the distribution of spotted gum on the Ordivician sediments as well as the Permian sedimentary parent materials. He indicated the extreme sensitivity of individual species to variations in edaphic properties. His study suggests a complex relationship between species' competitve advantage, soil chemical and physical properties as well as a number of other factors.

This extreme sensitivity to ecological parameters is a major argument against the indiscriminate extension of the distribution of valuable tree species. Florence (1968), for example, has cautioned against silvicultural practices aimed at extending the natural distribution of blackbutt in east coast forests.

3.1.2 Succession

The continuing change in the structure and function of vegetation communities is called ecological succession. All ecosystems respond to internal and external changes by successional changes.

A number of different successional processes have been identified (Griffith, 1977). The two major types of succession are primary succession and secondary succession. <u>Primary succession</u> is the process of initial vegetative colonisation of a site on which no previous vegetation existed. These sites include sand dunes, volcanic lava flows and ash deposits, and recently deglaciated terrain. <u>Secondary succession</u> is the process of vegetative response to perturbation of an existing plant community through, for example, severe fire, flood, erosion, or windfall.

The traditional theory of succession (Odum, 1963 and Kormondy, 1969), that of undirectional community development leading to a state of dynamic equilibrium through a number of floristic stages, at best only describes the initial stages of primary succession.

Once a certain ecological community has established itself on a site then this community plays a part in further changes through secondary succession. A number of different ecosystems exhibit different response mechanisms to community disturbance. This is logical in the light of the different physiological and morphological characteristics of the different vegetation communities. The natural softwood-hardwood associations of temperate New Zealand rainforests, for example, could be expected to exhibit different successional mechanisms to the dry sclerophyll eucalypt associations of Australia.

Some of the possible models of secondary succession have been presented by Connell and Slayter (1977). They term the traditional model of succession the 'facilitation' model which has been called the 'relay floristics model'. Models associated with <u>secondary</u> succession are the 'tolerance' model, 'inhibition' model and 'cyclic' model.

<u>Tolerance model</u>

This model of succession applies to the situation where a wide range of species may be present or invade soon after a major disturbance to the plant community. Thus species which dominate later in the succession are successful regardless of whether earlier species preceded them or not. These tolerant species are able to persist and then respond to expanded opportunities for growth because their demands on resources are lower.

Inhibition model

This model seems to explain best eucalypt forest succession after perturbation. Characteristics of this model may be summarised as:

a) a wide range of species occur on the site after disturbance,

b) there is a rapid colonisation of the site by most species and thus a rapid increase in diversity of species, and

c) some species so effectively compete for resources that they truncate, for a period, the succession to later species.

The relevance of the inhibition model to the eucalypt forest is suggested by observations on shrub development in the forests. For example, a considerable decline in the shrub component may occur if the community is protected from fire for about 40-50 years, in the case of snow gum, or 35 years under an alpine ash canopy (Park, 1975; Griffith, 1977, and Florence pers. comm.). The shrubs that decline are not replaced by other invading shrubs but are replaced by a grass and herb understorey. When a fire does occur, however, the long-lived seeds (often leguminous) of the shrub layer germinate and shrubs recolonise the site for a time.

As a eucalypt stand develops to a strong and competitive canopy, and with protection from fire, it often appears to quiesce succession. As a result both floristic and structural diversity may decline from a multi-tiered stand to a relatively simple tree-grass system with scattered residual shrub species.

Cyclic model

This model appears to incorporate aspects from both tolerance and inhibition models. Inhibition occurs at one part of the cycle and the process of tolerant trees eventually taking over becomes important at another stage. An example of cyclic succession was observed by Beveridge (1973) in scattered podocarp forest of the central North Isalnd of New Zealand. He outlined a cycle of six identifiable stages involving the occupation of the site by three distinct vegetation communities. Initially, after a mature podocarp is removed through windfall, tree-ferns occupy the site creating a dense fern canopy through which little light can penetrate. Hardwood species then germinate and establish epiphytically on the tree ferns and gradually develop and suppress the ferns. With the eventual elimination of tree ferns, bird distributed podocarp seeds germinate and develop under the declining hardwood canopy. With the death of the individual hardwood trees, podocarps again occupy the site as a group of saplings.

Succession in any forest ecosystem appears to follow variant mechanisms depending on the unique features of the system and its components. Various models have been proposed to classify the different mechanisms of vegetation change. The common ground between all mechanisms of succession is considered by Slatyer (1977) to be:

"i) the ability (probability) of a propagule being available at a site after perturbation, i.e. whether it is able to survive the perturbation or reach the site by appropriate dispersal mechanisms, and

ii) the ability of the propagule to become established at the site and reach productive maturity, in turn a function of the environmental requirements of the species, its adaptive ability, and its reproductive strategies in relation to the prevailing environment." (Slatyer; cited in Griffith, 1977)

The correct interpretation of the successional stage of forest vegetation can be critical to successful silviculture. Selection logging techniques, for example, will not normally ensure the perpetuation of stands formed as early successional stages after natural perturbations. Examples of this include the use of selection techniques in fire regenerated stands of alpine ash (<u>Eucalyptus delegatensis</u>) in Australia (Cremer, 1971), the Douglas fir (<u>Pseudotsuga menzieii</u>) forests in the Pacific north-west of U.S. (Leak et al, 1969) and the rimu stands (<u>Dacrydium cupressinum</u>) of the central North Island volcanic plateau of New Zealand (Herbet and Beveridge, 1977) all of which provide economically important timbers.

Another example of the importance of the correct interpretation of the successional stage of the stand can be seen in the management problems of the more mesic eucalypt forests. If the 'inhibition model' applies to this type of forest then the relationship between the level of stocking and the development and persistence of a dense mesophytic understorey can be understood. That is, the more frequent the disturbance, either by fire or logging (particularly where growing stock may be reduced below the level of full site occupancy), the greater will be the development of the understorey and the longer will regeneration be suppressed. As a result often only severe site disturbance will ensure adequate regeneration on such sites.

Alternatively, more conservative silvicultural techniques, aimed at maintaining higher levels of growing stock, may ensure the decline of the shrub understorey and thus necessitate less severe regeneration treatments.

3.1.3 Competition

Florence (1969) has discussed the relative importance of competition for light and nutrients, and competition through root factors between individual members of the stand. Competitive relationships between components of a forest stand may vary with forest types. Studies on spotted gum - ironbark associations of southern Queensland (Henry, 1960; and Henry and Florence, 1966) show that for spotted gum (often associated with harsher environmental conditions) competition between dominants in the stand and regrowth can be extreme. In comparison, blackbutt regrowth under more favourable conditions may be less affected by the competition of dominants at similar stand densities.

Thus the optimal stocking for an uneven-aged spotted gum forest will normally be lower than that for blackbutt if individual tree increment is to be maintained through all age classes. Because of the strong competition exerted by larger trees, spatial distribution of sizes in a spotted gum forest, indeed in any irregular eucalypt forest, will be an important consideration. For example, the larger the patches of even-aged growth in an irregular forest the more productive the stand may be.

Within any even-aged patch of any eucalypt forest competition between individuals in that patch will be strong, and the number of trees which can be effectively grown to specified sizes is small. For example, Curtin

(1970 b) has examined the size class distribution of a northern NSW mixed species spotted gum forest in Yarrat State Forest. This size class distribution is shown below in Table 1 as well as changes in stocking that have taken place over the six year inventory period from 1960 to 1966.

TABLE 1

Comparative size class distribution on Yarrat State Forest.*

Number of stems	Year	Size Class (cms dbh)							
		10-20	20-30	30-40	40-50	50-60	60-70	70+	Total
Useful	1960	9.9	6.4	3.8	1.3	0.36	0.16	0.2	22.12
	1966	16.8	7.0	4.3	1.9	0.44	0.16	0.16	30.76
Useless	1960	7.6	3.1	1.9	0.8	0.40	0.28	0.52	14.60
	1966	10.0	3.4	2.0	0.8	0.48	0.24	0.48	17.40
Total	1960	17.5	9.5	5.7	2.1	0.76	0.44	0.72	36.72
	1966	26.8	10.4	6.3	2.7	0.92	0.40	0.64	48.16

* Source: Curtin, 1970 b; NB. All species included.

The relatively small number (per hectare) of stems greater than 50cm dbh is readily apparent. The table also indicates a slight decline in growing stock over the inventory period for sizes greater than 60cm. The diameter progression through the size classes up to 60cm is , according to Curtin, encouraging. This indicates that there is a reasonable basis for continuing uneven-aged management where the pattern of diameter increment is to be maintained.

3.1.4 Regeneration

Regeneration studies in spotted gum - ironbark associations (Henry and Florence, 1966) indicate the importance of the lignotuber habit of spotted gum. Although this study was conducted in southern Queensland, the results can be taken as applicable to southern NSW. Features of this regeneration study are summarised below.

1. The pool of lignotuber advance growth remains fairly stable over time.

2. Seedling regeneration after fire may be substantial. There is a marked response to the ash bed in terms of germination and seedling growth. However, the survival rate of seedling regeneration until it reaches the lignotuber stage is very low.

3. Once the regeneration has survived long enough to establish a lignotuber and thus enter the lignotuber pool, it is more capable of withstanding stress such as fire, drought, browsing or logging damage.

4. Competition from the overwood maintains much of the advance growth in a suppressed state. Much of this advance growth may persist in the straggling lignotuber form.

5. A reduction in competition through partial or complete removal of the overwood usually results in a temporary rapid growth of lignotuberous advance growth until competition again sets in.

6. Lignotubers will generally not persist under low light conditions, for example, under a dense shrub understorey. Thus on moist sites, where meso-phytic species may have caused a decline of the lignotuber pool, simply removing the overwood may not result in the usually adequate regeneration associated with dry sites. Alternative silvi-cultural treatment to provide a seed bed, such as burning or soil scarification, or direct planting may be necessary.

The use of fire to ensure regeneration in moist eucalypt stands has been examined by Floyd (1962 & 1976), and Cunningham and Cremer (1965). Under moist conditions the initial response to the ash bed can, however, be capitalised by woody 'fire weed' species rather than by the commercial tree crop. For this reason regeneration treatment during and after logging needs to suppress prolific weed growth yet provide sufficient light and space for the establishment of seedlings. Mechanical site preparation methods have therefore been considered (Floyd, 1965; and Weir, 1968) and their increasingly widespread application throughout the mesic forest types of New South Wales, especially in subtropical northern NSW, reflects the success of this treatment.

3.1.5 Condition of growing stock

The condition of existing growing stock can place significant constraints on the silvicultural decision. For example, in old-growth stands consisting largely of overmature and senescent trees, there is no justification in thinking in classical selection logging terms due to the lack of sufficiently vigorous advance growth. The nature of growing stock resulting from previous logging and its silvicultural history will place some constraints on the silvicultural decision.

Curtin (1970 a), for example, suggests that present stand productivity is limited by the proportion of present growing stock in a marginal or useless condition, given the present markets for much of the NSW forests. This applies to nearly all State forests irrespective of the quality of the forest or the degree of stocking. Table 2 below illustrates the Statewide condition of eucalypt forests most of which have been managed, more or less intensively, for a number of decades.

TABLE 2

A Comparison of Useful and Useless Growing Stock in Some NSW State Forests[1]

State Forest	Stems per hectare		Volume (m^3) per hectare	
	Useful	Useless	Useful	Useless
Coopernook	21.8	21.8	1.8	0.2
Benandra[2]	20.2	16.2	1.4	0.3
Kendall	19.8	15.7	1.4	0.7
Coffs Harbour	15.4	29.1	1.1	0.6
Wyong	18.2	13.7	0.8	0.5
Kioloa[3]	16.2	18.6	1.8	1.2

1. Based on Curtin (1970 a).
2. From Furrer (1971); p34.
3. From Furrer (1971); p41.

Curtin (1970a) contends that future forest production should not be based on stands with such a high proportion of marginal and currently useless material. He maintains that calculation of stand yield in perpetuity should recognise the potential of silvicultural treatment to increase stand productivity through less conservative, more responsive silviculture.

Neverthless, the application of certain silvicultural practices such as selection marking for retention based on defined standards of bole and crown quality can, in practice, result in almost clearfelling the stand where there is a high proportion of marginal and useless material. This result may not be appropriate in terms of the product supply constraint (to be considered later) if, for example, a continuing supply of sawlogs is required in the short term.

3.2 Silvicultural alternatives

The biological factors already briefly mentioned pre-determine the range of methods available for the production of both wood and non-wood products under the constraints of economics, environment and technical efficiency. This range of methods can be classified into groups of varying impact for the purpose of discussion.

3.2.1 Classification

The alternative silvicultural methods can be classified on the basis of the origin of regeneration and the extent of disturbance to the forest structure. Regeneration can be considered, for the purposes of this classification, to result from seed, established seedling stock (including lignotuberous growth) and coppice.

A Even-aged methods

1. Clearcutting methods result in maximum disturbance to the site by removal of the entire tree stand, and where windrowing and burning are used to prepare the seed bed, by removal of all vegetation in the stand. Subsequent artificial or natural seeding produces an even-aged stand.

2. Seed tree methods approximate clearcutting except that adequate natural re-seeding is assured by the retention of appropriate trees within the stand as seed sources (Cremer, 1971).

3. Shelterwood methods may involve less disturbance to the site while ensuring even-aged regeneration, principally from seed. This is achieved by a series of two or more harvests in close succession providing regeneration with shelter during germination and early seedling development.

B Uneven-aged methods

1. Single tree selection causes the least disturbance

to the forest. Individual trees may be removed at maturity, but the method does not necessarily depend on the removal of the largest or highest quality trees. This method relies primarily on established seedlings for regeneration; frequently these seedlings are shade tolerant species.

2. Group selection methods may be used as a compromise to ensure the regeneration requirements of desired species are met, while minimising disturbance to the forest. Seedling requirements for light and freedom from competition may determine the size of the individual regeneration group.

C Coppice methods

1. Simple coppicing achieves regeneration primarily from the coppice shoots of cut stumps. The small size and sometimes poor quality of wood produced by this method has restricted application to areas supporting small-wood markets (Carter, 1974).

2. Integrated coppice methods combine short rotation coppice methods with longer rotation sawlog methods within the same stand by controlling the stocking rate. Individual tree spacing is manipulated to ensure a certain proportion of stems develop to sawlog size.

The classification system presented above summarises the spectrum of silvicultural techniques available but it also masks the subtle variations between classes. Silviculture should be considered a continuum of available alternatives ranging from clearcutting with artificial planting to single tree selection. It may be appropriate, to meet certain objectives, to apply a number of different silvicultural techniques to the one stand. "No silvicultural procedure is so universally applicable that it deserves to be viewed as anything approaching standard operating procedure." (D M Smith, 1972).

Where factors other than wood production are important in stand management, the continuing development of silviculture may be characterised by an acceptance of flexibility in the use of the infinite variations possible, rather than by an increase in the range of silvicultural techniques available. The future development of silvicultural practice is seen by D M Smith to depend on the legislative and public endorsement of a necessarily flexible management approach using a full range of appropriate silvicultural alternatives.

3.2.2 The effect of inflexibility in silviculture

Smith (1972) and Florence (1970 and 1972a) discuss the effects of U.S. and Australian adherence to insensitive, strict silvicultural systems. In the case of spotted gum forests of the NSW South Coast, this history of limited silvicultural sensitivity has resulted in a range of stands of varying productive potential. The initial application of selection logging in the South Coast spotted gum stands was probably too conservative and resulted, more often than not, in the release of long-suppressed saplings and advance growth. After a couple of cutting cycles of this conservative treatment the ability of the residual stems to respond to release is very limited indeed. The recent application of widespread clearcutting methods has increased stand productivity (Florence and Shepherd, 1975) but at some cost to environmental and non-wood values.

Phillis (1966) examines the ecological implications of certain silvicultural treatments in irregular eucalypt forests. One of the main advantages, he points out, of a strict prescription method of treatment is that a set of rules can be applied by untrained personnel. However, a strict prescription approach fails to appreciate species (both in terms of regeneration and potential to grow under competition) and can result in considerable variation in stand productivity. He concludes that the maintenance of productive stands of eucalypts requires a silvicultural approach more responsive to variations in ecological requirements of the desired species. For example, the maintenance of a fully stocked stand of near pure *E. pilularis* on a more mesophytic site may require such methods as clearfelling with seed trees or clearfelling over large coupes. Alternative selection methods relying on natural regeneration may be quite appropriate elsewhere within the same forest and 'forest type'.

3.3 Constraints operating on the silvicultural decision

The silvicultural decision - specifying the nature and timing of forest management - involves a resolution of biological, economic and environmental considerations within the constraints of supply commitments and technical efficiency. For example, supply constraints can influence the attitude to existing growing stock in intermediate and other advance growth sizes. Financial maturity and product size considerations can determine rotation length. Funding for non-commercial treatment may limit silvicultural alternatives. Environmental considerations (including catchment and wildlife values) may increase harvesting costs, reducing funds subsequently available for silvicultural operations. Emphasis on aesthetic values can restrict the range of silvicultural options by decreasing group size, affecting group shape and distribution, restricting the timing of silvicultural treatment or removing critical areas from production altogether.

3.3.1 Supply Constraints

The influence of supply constraints on the silvicultural decision can be discussed in terms of the Batemans Bay Sub District wood supply commitments. These are summarised in Table 3 below which shows the Sub District production for the 1975-76 financial year.

This table illustrates that the requirements of the timber market in this area are for the average to high quality products. The limited scope for economic utilisation of small poor quality thinnings is notable.

TABLE 3

Batemans Bay Sub District Wood Products 1975-76 [1]

Product	Volume
Sawn timber	53 983 cu.m.
Miscellaneous hewn	8 cu.m.
Piles	17 cu.m.
Poles	2 033 cu.m.
Mining timber	6 318 cu.m.
Fencing	85 cu.m.
Furnace Poles	1 184 tonnes
Fuel	36 tonnes
Eucalyptus oil	698 litres

1. Source: NSW Forestry Commission Annual Report, 1976.

Not only is the majority of production in the larger size range but as Table 4 below shows, individual piece size is large also. This suggests that any silvicultural decision should be directed to maintain the continuity of supply in the large size classes, and that husbanding of existing growing stock in intermediate and larger sizes will be important in the silvicultural decision.

Another feature of market demand in this region is the instability of demand over time. Duggin and Saunders (1978) outline the supply history for wood products of the NSW South Coast and highlight the importance of sawn

TABLE 4

Minimum utilisation dimensions for some forest products[1].

Product	Minimum d.u.b.	Minimum length
Sawlogs (sound)	30cm (centre)	3 metres
" (defective)	40cm (centre)	5 "
Poles	18cm (small end)	9 "
Mining timber		
Props	10cm (small end)	1.8 "
Bars	12cm (centre)	3 "

1. Source: NSW Forestry Commission, Wood Technology and Forest Research Division.

timber and mining timbers. They also note the intermittent demand for poles, girders and railway sleepers, but suggest that demand for poles is expected to stabilise by the early 1980s. This intermittent pattern of demand restricts the predictability of economic returns on silvicultural treatment. Such uncertainty may severely constrain the silvicultural decision especially in a restrained financial climate.

3.3.2 Environmental constraints

A number of biological and physical values are implied under the heading of environmental constraints. These include flora and fauna conservation, soil and water conservation, and the provision of landscape and aesthetic resources for recreation use. The impact of such considerations on the silvicultural decision varies in magnitude and nature depending on particular aspects of the resource and its use. This section will briefly illustrate some of the ways in which environmental considerations may influence silviculture. A more detailed examination of the information required to make the silvicultural decision in the face of these constraints is the subject of section 4.2.

The influences of flora and fauna conservation on the silvicultural decision are not simply restricted to the need for preservation of ecological types within native forests. Silvicultural management for wood production can be carried out in such a way that wildlife values are maintained or even enhanced. Thus management for conservation values must be an integral part of overall forest management to ensure the continuing role of important indigenous forests in both conservation and wood production. Florence (1972b) for example, examines the possibilities of silvicultural management of native forests for wildlife habitat as well as wood production. He highlights the problem of predicting the impact of habitat changes on wildlife species.

There are a limited but increasing number of studies directed to this question, for example, it seems to be now well accepted that arboreal species such as the greater glider cannot survive substantial modification of high forest (Tyndale-Biscoe and Smith, 1969, Suckling et al, 1976 and Nicol, 1978). Other studies have established the importance of substantial understorey to small ground-dwelling mammals (Suckling and Heislers, 1978).

Specific influences of water and soil conservation on the silvicultural decision are considered in section 4.2.4. The major constraints are placed on aspects of harvesting operations but some constraints are placed on silviculture. Removal of trees from riparian strips, for example, is not often permitted. This type of constraint could, in some instances, severely limit the amount of wet sclerophyll forest available for production. Other important aspects of soil and water constraints include slope, parent material, intensity of logging, and restrictions on regeneration treatment methods.

The provision of aesthetic values from forests can become a significant consideration in forest management. These values are important where the forest tract is located in areas of high landscape sensitivity (such as an urban backdrop or visual corridor) or in areas of high recreation use. In either case visible forest areas are extremely sensitive to public interpretation of the silvicultural decision. The information required and techniques of landscape and recreation management are discussed later. In most instances, therefore, silviculture is restricted to conservative practices with the aim of maintaining stand structure for aesthetic reasons.

3.3.3 Economic constraints

Economic constraints on the silvicultural decision can be discussed in terms of financial considerations and investment considerations.

Financial effects on the silvicultural decision are related to availability of funds for expenditure on silvicultural treatment. Finance available for silviculture may be restricted by the level of immediate returns on the operation. For example, clearfelling can be more attractive than other harvesting methods because of the higher overall return. However this must be balanced against the "non-productive" aspects of clearfelling, i.e. the costs involved in removing unmerchantable growing stock, site preparation, and so on.

Immediate financial returns can determine whether a stand is logged or not. Quite obviously it will be uneconomic to log if the harvesting and processing costs are greater than the value of the product on the market. For example, for the South Coast forests Duggin and Saunders (1978) define a number of constraints related to this question. Among these they include distance from the coastal highway (a maximum of 80 km) stand merchantable volume (an absolute minimum of $8m^3$), and slope (a maximum of 20% for economic extraction).

Investment in silvicultural treatment (of either existing growing stock or regeneration) can often be constrained by a concern for economic efficiency, i.e. return on investment. For example, (Henry (1960) examined several silvicultural practices in spotted gum - ironbark forest in south east Queensland. While the results of this study will not now be directly applicable to the spotted gum forests of the NSW South Coast, they do highlight the effect of investment considerations on the silvicultural decision. Table 5 summarises the return on investment of silvicultural expenditure in terms of average annual increment in merchantable volume. The plot was established, and treatment applied, in 1938. The forest had been heavily logged in the past and was well stocked with regeneration prior to treatment. Minimum treatment involved ring-barking useless species and useless stems of desirable species. The routine treatment involved ring-barking useless species and stems as well as thinning remaining crop trees to certain spacings dependant on stand height. Also competing weed vegetation was removed and regeneration was encouraged by coppicing.

TABLE 5

Returns on silvicultural treatment[1]

Treatment	Cost of treatment ($/ha)	Annual value increment ($/ha 1938-58
Control	-	0.04
Minimum treatment	0.24	0.09
Routine treatment	0.40	0.11

[1]After Henry (1960).

This table highlights the response of merchantable volume increment to even minimal silvicultural expenditure. As well, the table shows the additional value increment resulting from additional silvicultural expenditure. The marginal increase, from 9¢/ha to 11¢/ha, resulted from a substantially greater increase in silvicultural expenditure from 24¢/ha to 40¢/ha. Henry (1960) argued from this that while some silvicultural treatment was justified, the higher cost of routine treatment was not justified in comparison.

3.3.4 Technical efficiency constraints

The constraints imposed by considerations of technical efficiency relate to roading, harvesting, levels of wood production, unit costs, measurement and regulation of cut, supervision of operations and logging control. They also relate to efficiency of management, operations and logistics, and the effective deployment of skilled and unskilled personnel.

A strong case can often be made, on the grounds of technical efficiency, that clearfelling is the most appropriate silvicultural approach. This may be true in many instances especially when wood production has major significance (such as pulpwood concession areas), but disproportionate weight should not be given to this factor in the silvicultural decision in all cases, especially where the major demands are for other forest benefits.

An example of a forest with significant demands for other forest benefits is the forested area of Fraser Island, Queensland. The Commission of Inquiry into the environmental effects of sand mining on the island (Fraser Island Environmental Inquiry, 1976) declared that the entire island represented an area whose particularly sensitive and delicately balanced environment was worthy of being recorded as part of the National Estate. Particular silvicultural practices such as clearfelling, the use of chemical treatments in the thinning of stands, and regeneration burning, while technically efficient in terms of wood production, were seen by the Commission as incompatible with the achievement of certain environmental objectives.

3.4 History of management of the South Coast forests

The silvicultural background to much of the South Coast forests has been largely one of exploitation. This can vary from single tree selection of the highest quality boles, to complete removal of all trees of commercial quality. During the exploitive phase of the forest history little regard was given to the productivity of the remaining forest. Much of the residual stand growth was focused on stems of poor quality, and at times the stand was not able to take advantage of unused site capacity (Florence, 1972a).

The development of management of these forests can be considered in relation to a number of phases. These phases are the application of advance growth salvage, Australian Group Selection, and more recently, clear-cutting.

When early management was imposed, the first improvement treatment, in conjunction with selection logging, involved a ringbarking programme aimed at removing poor quality trees, thereby concentrating increment on stems of greater value. Advance growth salvage is a term commonly given to this type of treatment. The treatment implies that enough regrowth which has accumulated within the stand as a result of a series of past disturbances, and covering possibly a range of tree sizes, can form the basis of the next crop after its release from any competing overwood. While this treatment succeeded in concentrating growth on some of the better stems of the intermediate size classes it was not entirely successful in all cases because of the physiological age and inherent poor vigour of much of the advance growth, nor was it entirely successful in maintaining recruitment of regeneration into the smaller size classes.

In later treatment this ringbarking and release treatment was extended to encourage new regeneration. Much of the regeneration of these stands results from the release of small stems from the lignotuber pool.

Henry and Florence (1966) indicate the effects of total canopy removal on stimulation of growth of lignotuberous regeneration in spotted gum - ironbark stands. Because the removal of old growth trees was rarely complete, ringbarking treatment had variable effects in promoting continuing growth of spotted gum. The long-lived lignotubers of many eucalypts are able to respond to release from competition but the competitive effects of any remaining stems extend well beyond the edge of their crowns. Thus some patches of regeneration developed well while other patches were restricted by continuing overwood competition.

Additionally, the occurrence of lignotuberous regeneration is influenced by site factors. Furrer (1971) notes that of the spotted gum types on the South Coast, the drier types respond well in terms of lignotuberous regeneration. In the wet sclerophyll types weed competition not only reduces the longevity of lignotubers but reduces the potential for their release. The lack of adequate regeneration on the higher quality sites was one factor leading to the practice of group selection. Thus group selection developed largely in response to observations on the ecological nature of the eucalypt stand.

Natural groupings of young regeneration were said to occur due to the death of single large trees creating gaps in the canopy of sufficient extent to free advance growth from competition. Under group selection artificial gaps are created during felling operations. Patches of commercial trees are removed in logging and any remaining trees in the patch are felled and the gap widened if necessary. An additional advantage of this system is the effect of treatment on trees bordering the gap. These trees may be able to capitalise on the reduced competition, and faster rates of diameter increment may be attained.

Furrer (1971) relates much of the successful regeneration under group selection treatments on South Brooman S.F. to the size of the gap created by treatment. Irrespective of the size of the gap, however, regeneration of mesophytic forest types was not always successful without substantial soil disturbance. However, high levels of expenditure are frequently required to regenerate the mesophytic forest type, and in the absence of such treatment logged forest in moist gullies may not fully utilise the site.

In earlier decades of forest management clearfelling was rarely practised. Where areas were cleared they normally involved only small groups of trees. Clearfelling was attempted for the first time on a larger scale in the South Coast spotted gum - ironbark forests on Kioloa S.F. in the mid 1960's. Adequate regeneration of 740 to 980 stems per hectare was obtained with an initial height growth of up to 3.5 metres over two years (Furrer, 1971). Similar treatment resulted in only 247 stems per hectare on another site, probably due to the effects of drought.

The practice of clearfelling has not gained widespread acceptance in this area for a number of reasons. These include the wide variation in regeneration success, the comparatively slow early growth of spotted gum, and the high costs of site preparation associated with clearcutting. In view of these and other constraints there does not seem to be any justification for clearcutting on a wide scale. Continued clearcutting would be justified only if conversion to even-aged stands as quickly as possible were justified. This appears to be unlikely in the short term because of the requirement for sawlogs in the immediate future.

The present condition of much of the forest subject to this history of management is characterised by wide variations in stocking, standing value and growth rates. In general, though, the area is poorly timbered both in terms of growing stock and potential immediate yield.

CHAPTER IV

INFORMATION REQUIREMENTS

> "We need more definitive, applied information on ecology so that our management decisions can be based on facts. In respect of forestry environmental questions, it is essential that foresters continue with appropriate research and technique development of an applied nature. An ecosystem approach is not new to foresters, although today the approach is much broader. The forester need not fully comprehend hydrology or human health, but he must appreciate the need for having these factors evaluated." (Kunkle, 1975)

The preceding chapter covered in outline the sorts of factors which might be taken into account in developing the silvicultural decision. The information required to make sound management decisions will now be examined in the light of specified management objectives for South Coast forests.

4.1 Objectives of management

The general policy of the NSW Forestry Commission on forest use and management was outlined in section 1.4. This policy specified that the coastal forests should be managed for wood production and recreation without specifying any method of arriving at a balance between the two uses, nor whether recreation is to be given dominant status under any circumstances.

In practice many areas of coastal NSW State forests are accorded status as recreation areas, where recreation is the dominant use, and the South Coast is no exception to this practice. The particular forests in the Kioloa area, however, provide far more benefits than recreation and timber production alone. Other benefits include water and soil conservation on the coastal plain and water yield for livestock and recreation uses, an aesthetic backdrop to resort settlements, and wildlife and flora conservation values both through the habitat provided in State forests and through the forest's proximity to Murramarang National Park. All these values should be recognised in the objectives of management.

4.1.1 Wood production objectives

Wood production objectives have been given priority in State forests due to historical and legislative influences. This objective is likely to remain the primary aim of State forest land use at least in relation to the State's forests as a whole. The forests of the South Coast will continue to be managed for wood production and this production should be sustainable in perpetuity throughout the Kioloa group of forests. As well, the production of sawlogs over the next 30 years is to be maximised.

Overall maximisation of wood production in terms of volume output or stumpage revenue is not a stated objective. In fact the NSW Forestry Commission policy assumes a low level of sustained output from these forests with corresponding adjustments in the native timber processing industry in response to a decline in supply. While this approach minimises investment in forest operations, it also effectively restricts stand yield as discussed in section 3.1.5. This approach fails to recognise the full potential to increase yield through silviculture aimed at improved productivity.

In the long term State indigenous wood production is to be controlled to a level sustainable by the forest. It would seem appropriate then that the primary objective should be to improve forest productivity so that as much as possible of the industrial demand for wood can be met.

4.1.2 Non-wood objectives

The dominant use approach to multiple use management requires that a balance between uses be attained on an area basis, through primary zonation for dominant uses, while at the same time being aware of compatible secondary uses. It is for this reason that information on the compatibility of various primary and secondary uses becomes vitally important.

The technique of providing resources to meet the demand for various non-wood benefits by zoning different parts of the forest for a single use will be inappropriate. The aim will be to provide for the demand as both a primary and secondary use of the forest. Primary use would involve setting aside particular areas of the forest for that use. Particular uses that would require dominant status include picnic and camp sites where open spaces are required, and areas where conservation values, such as particular wildlife habitat or vegetation communities, cannot withstand disturbance. Secondary use status should be given to certain uses in areas where additional benefits can be obtained from other compatible uses. Landscape values could thus be given secondary status, and where views are sensitive to wood production activities these would be undertaken subject to certain constraints. The same would apply to wildlife populations that can sustain a certain amount of disturbance to their habitat, and to mobile recreation activities such as driving and bushwalking.

On the South Coast certain areas will not be zoned for wood production because they contain scrub or non-forest vegetation. These areas are immediately available for some other form of use, normally recreation, but occasionally they contain wildlife of particular local interest. The extent to which productive forest land is zoned primarily for other uses is the basis of the multiple use decision and as such will require information on both the demand for alternative uses and on the ability of the resource to facilitate that use.

In short, the objectives of management of the South Coast forests will be to:

1. Maximise the production of sawlogs over the next 30 years.
2. Maximise timber yield on all areas zoned primarily for timber production subject to the constraints, if any, of secondary uses.
3. Provide areas zoned primarily for other uses, particularly recreation and wildlife and flora conservation, appropriate to the balanced use of the forest.

4.2 Major forest uses

The information needed to determine the appropriate balance between major forest uses, namely timber production, recreation, biological and soil and water conservation, and landscape protection will now be considered.

4.2.1 Timber production

Information on the demand for timber production is readily available, and the nature of this demand on the South Coast has been examined in section 3.3.1. The future demand for indigenous hardwood timber is, however, expected to be less stable than that of other wood products (Bootle, 1976). Past trends in demand for hardwood timber may not continue once plantation grown softwoods become established in the sawn timber market (FORWOOD, 1974). The proportion of softwoods in the sawn timber market is expected to increase. This may not, however, reduce the overall demand for sawn timber from State indigenous forests. The demand for other traditional products including poles, piles, sleepers and mining timber from these forests is expected to continue at a low but relatively stable level (Duggin and Saunders, 1978).

Information on the ability of the forest to produce this wood is essential to the silvicultural decision and, if productivity is to be increased, a detailed knowledge of the ecology of the mixed species eucalypt forest will be needed.

4.2.1.1. Ecological characteristics

The fundamental view of a forest is that of a forest ecosystem. An ecosystem can be delineated at a number of levels from the single tree to the global forest zone, but for forest management purposes the individual stand of a certain 'forest type' is the most common unit.

Patterns and processes within the forest ecosystem are most readily identified at two levels. Firstly, at the broad forest type level and secondly, at a finer level recognising differences in site, species representation, and relationships between species and understorey. This latter level has been referred to by Florence (1978) as the more 'ecologically meaningful level'.

Forest type mapping has long been recognised as a useful base for silviculture. However, by no means are all managed forests mapped on this basis. It has been a traditional practice in many NSW State Forests to simply map forests on the basis of standing timber, that is, volume mapping. Clearly such a management base assumes a single use.

Even broad forest type mapping is of limited value to the silvicultural decision. The Commonwealth Scientific and Industrial Research Organisation (CSIRO) South Coast Project, for example, delineated broad forest types for the South Coast area. The scale of definition is such that differences in site, topography and species proportions are not fully elucidated. This lack of detail severely restricts the usefulness of such a survey for forest management purposes, which is only to be expected when it is appreciated that the survey was designed to aid the land use decision and not the silvicultural decision.

Ecological management of a forest involves an understanding of <u>ecological pattern</u> and <u>ecological processes</u>. What is required, therefore, is a detailed base of information at a scale that reflects changes in species representation over a single forest type, one that reflects the influence of site factors not only on the standing forest but also on the reproduction of that forest. Florence (1978), for example, highlights the importance of site factors on regeneration, relative competitive ability and succession as well as the incidence of forest pathogens. Many of these ecological characteristics have been discussed in the previous chapter. Examples of the influence of site on forest development have been presented (e.g. the soil-plant relationships on Kioloa S.F.). The influence of site on regeneration and succession (in terms of the 'inhibition' model) have also been discussed in general terms. This type of information requires the use of techniques of statistical ecology, definition of pattern in vegetation, analysis of relationships between vegetation pattern and environment, and testing the extent to which ecological units can be recognised and used as a basis for varying the silvicultural decision.

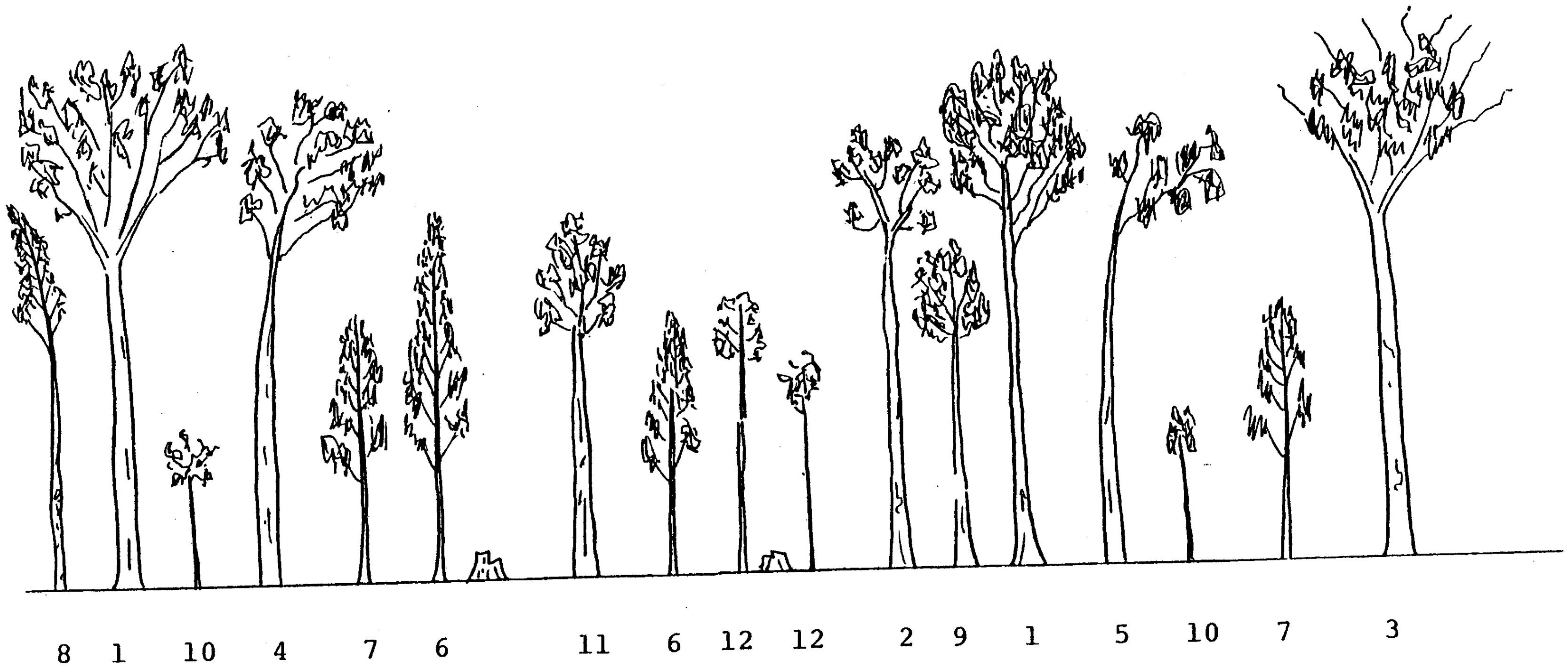
One of the aims of producing such a detailed data base for management of irregular forest is to attempt to optimise wood production, through silvicultural methods, under the various constraints imposed by other considerations in a multiple use framework. Ensuring optimum production requires an understanding of the ecological response of various forest types on different sites to silvicultural treatment. Thus growth information is essential.

4.2.1.2 Growth characteristics

The importance of growth information in forest management has been emphasised by Beers (1962) and Davis (1964). Beers, for example, highlights the difference between measuring forest performance, using techniques such as random plot sampling, and measuring forest response to treatment through permanent plot inventories. The former accounts for growth and drain, whereas the latter is essential for designing future management methods.

Past studies of quantitative growth in irregular forests have relied on the classification of stand components along traditional lines. Authors such as Phillis (1971), Curtin (1970 b), Turner (1966), Trimble (1969) and Vanclay (1977) have tested the application of crown and vigour classes as predictors of individual tree growth. These predictors, however, failed to take account of past silvicultural history and the development of individual trees to their present status within the stand. As such, preditions based on these traditional classifications were subject to error. This error became more significant as the proportion of visually young, yet physiologically old, trees increased.

A good example of the sort of information required for silvicultural planning is that recently presented by Keady (1978) working in South Coast forests. He analysed in detail various parameters affecting different components of an irregular spotted gum stand. In an attempt to better



Crown Quality Classes

FIGURE 5

Plate D

Spotted gum of varying form,
bole and crown qulaities.

explain observed growth patterns he identified three major stand components; (a) mature dominant trees, (b) pole regrowth trees, and (c) other or advanced growth forms. Significant differences in diameter increment and bole height growth were found for each of the three components.

The three major stand components were further divided into a total of twelve crown quality classes. Each class qualitatively incorporated an assessment of the silvicultural history of the tree, as well as an interpretation of its potential to further increase its status within the stand. Table 6 summarises the main categories of the crown quality classification. Although the categories are qualitative their interpretation was found to be relatively straightforward and reproducible. Figure 5 illustrates a stylised forest profile identifying each of the 12 crown classes. A comparison of Figure 5 and Table 6 will highlight the type of interpretation necessary for this classification. Note, for example, trees in classes 5, 10 and 12. These trees would not be expected to successfully respond to release even though they have often been considered a part of the advance growth component of the stand. Also note the presence of old stumps in the profile - an important interpretative feature of regrowth stands. Of the six advance growth stems adjacent to those stumps in the figure, only two could be considered capable of high productivity. (Plate D)

TABLE 6

Summary of the main categories of the Crown Quality classification.[1]

Stand component	Growth history	Crown quality class	
MATURE DOMINANT TREE Large size tree with extending permanent branches. Has, in terms of space, room to grow.	NO EVIDENCE OF PAST SUBSTANTIAL GROWTH RESTRICTION. A reasonable bole height with no major crown distortion.	GOOD MATURE CROWNS, WELL BALANCED, LEAFY.	1.
		MEDIUM TO POOR CROWN NOT DUE TO COMPETITION (e.g. excessive bifurcation or poor leafiness.)	2.
		SENESCENT, DISEASED OR HEAVILY DAMAGED TREES Due to dieback or fire.	3.
	EVIDENCE OF PAST SUBSTANTIAL GROWTH RESTRICTION. May have distorted crown, low crown breaks or accentuated branch development.	FAIRLY EXTENSIVE CROWN GOOD LEAFINESS AND MODERATE VIGOUR.	4.
		POOR WEAK CROWNS. May be heavily damaged.	5.
POLE REGROWTH TREES Active crown height growth evident, semi permanent lower branches,no evidence of growth restriction		GOOD POLE, HIGH VIGOUR (Straight bole with compact conical crown)	6.
		MEDIUM POLE AND VIGOUR Setback usually due to competition, sometimes disease, fire or wind.	7.
		POLE LIKELY TO MEET SUBSTANTIAL COMPETITION IN NEAR FUTURE.	8.
OTHER OR ADVANCED GROWTH FORMS. Not either of the above types, must have evidence of past restriction.	OVERTOPPED OR SUBSTANTIAL SIDE COMPETITION.	LOOKS CAPABLE OF CONTINUED GROWTH.	9.
		POOR CROWN, LITTLE GROWTH EXPECTED.	10.
	NO MAJOR PRESENT COMPETITION. i.e. In a state of release.	LOOKS CAPABLE OF REASONABLE GROWTH.	11.
		WEAK CROWN, LITTLE GROWTH EXPECTED.	12.

1. Source: Keady (1978)

The usefulness of this classification when compared to the traditional Dominance versus Crown Class or Vigour Class classifications is the higher degree of correlation between various Crown Quality Classes and parameters of silvicultural interest, i.e. diameter increment and bole height. Analysis showed that many of the 12 individual classes have unique properties in terms of the measured parameters and the way they are affected by interacting variables.

A complex interactive model was chosen by Keady as the best predictor of diameter increment. A number of interacting terms were significant in this model. For example, within the Crown Quality Classes 1 to 5 a relationship was found to exist between crown quality and species in terms of diameter increment. Most species groups showed appreciable differences in growth rates with varying crown quality. In most cases Classes 3 and 5 exhibited the lowest growth rates compared to Classes 1, 2 and 4. Dominant stratum spotted gum, however, showed the least response to changing crown quality, i.e., spotted gum in the dominant stratum grows at a relatively constant, yet slow, rate with comparatively little response to increasing levels of crown quality. For example, average periodic mean annual diameter increment (PMAI) for spotted gum Class 2 was approximately 0.35 cm/yr, but Class 1 trees of the same species grew only at a rate of 0.55 cm/yr (a 57% increase) whereas many of the other species exhibited a 100% increase between the two classes.

Other interactions were found between diameter (DBHOB) and crown quality of the dominant stratum trees in terms of PMAI, and between bole height and vigour class. The collection of this type of information is essential in providing the necessary understanding of the detailed relationships between ecological and wood production parameters in an irregular forest. The silvicultural implications of this type of growing stock and growth analysis will be examined in Chapter 5.

4.2.1.3 Growing stock control

Methods of irregular forest management rely on the regulation of wood removals and the control of retained growing stock (Alexander and Edminster, 1977 a & b; and Vanclay, 1977). In essence, management aims to maintain a specified size class distribution over the forest as a whole.

The control of growing stock, as practised in the irregular eucalypt forests of the NSW South Coast, has been influenced by an incomplete knowledge of previous forest management and current forest condition. Heavy reliance has been placed on the use of periodic management inventory (PMI) plots as indicators of current forest condition, and little attention has been given to the maintenance and use of compartment history records to monitor historical forest development.

The success of growing stock control based on PMI plots has been variable and the present supply situation (characterised by a relative shortage of sawlogs over the next 30 years) may reflect in part the failure of the PMI as an adequate indicator of the general forest condition. It is now apparent that in the past the PMI sampling procedure underestimated the importance of historical forest development and treatment.

The application of an interpretative tree classification, as proposed by Keady (1978), to the periodic management inventory may provide a measure of past stand treatment. This, however, should not be a substitute for keeping compartment records of silvicultural treatment.

Irregular eucalypt forest management has, therefore, proceeded in many areas without adequate information on the condition of growing stock in terms of size and quality class distribution throughout the forest. Continued production and improved productivity within these forests will be contingent upon the collection of this type of information. Thus a commitment to an inventory in which this information is adequately sampled is essential to proper forest management.

In order to provide all this information on ecological, growth and growing stock charactistics the inventory would need to be intensive and detailed. It would have to integrate information collected through a detailed bio-physical survey with sample data on tree growth and growing stock distribution.

The bio-physical survey should provide information on soils, hydrology and topography in sufficient detail so that individual stands can be compared with the data base. The forest type maps that are currently used need to be more detailed to include more closely defined ecological forest types, dependent to a certain extent on understorey species. The information on understorey is likely to be useful as an indicator of changes in various physical parameters such as parent material, soil type, soil moisture, level of water table and so on. It will also be useful in other fields such as indicating habitat types, recreation potential, aesthetic values of stands, conservation values and fuel types (for fire control purposes).

Data on the relationship between tree growth and tree characteristics such as diameter, crown quality and bole height for each species will need to be integrated with information obtained through the biophysical survey to establish more detailed relationships between tree growth and forest type, understorey components and stand stocking. Following this a fairly detailed sampling procedure would be required to determine the condition of growing stock in relation to the detailed species groups defined by the bio-physical survey.

4.2.2 Recreation

Present trends in demand for all forest uses show that demand for recreation is increasing at the fastest rate (FORWOOD, 1974; Panel 3). Due to the location and nature of the spotted gum forests north of Batemans Bay, this increased demand for recreation opportunities may be expected to have a significant impact on the use of the forest. The aesthetic quality of spotted gum forests has long been appreciated by the public and foresters alike. The particular combination of coastal habit, good tree development and form, and the characteristic mottled bark of the species combine to create a stand of high visual character. The forests are located within a short distance of Batemans Bay, a noted centre for tourism, and Murramarang National Park where they form an important visual backdrop to access routes to the national park and along the major coastal highway. All these factors lend weight to the expectation that certain areas within these State forests may become more important for recreation than wood production.

This increased demand for recreation opportunities could ultimately result in the removal of some stands from timber production, thereby increasing the pressure on the remaining stands to meet the demand for wood products.

Duggin and Saunders (1974) contend that active recreation on the NSW South Coast is concentrated on coastal areas where water-based activities predominate and forest areas are more likely to be used for passive recreation. This is substantiated by the distribution of current recreation pressures on various sites in the Kioloa and Benandra area. The greatest use is made of sites within State forest and national park which are adjacent to beaches, lagoons and rivers. The extent of this use is such that the sites themselves are already suffering from the impact of recreation use. Certain sites, and in particular sensitive dune areas, have been denuded of vegetation through the effects of vehicle movements and firewood collection.

Scenic routes have been established in the area for passive car-based recreation. The Kioloa Drive in particular is a significant attempt to meet the increasing demand for this type of recreation. The route through the forest has been upgraded to an all-weather access and has been well sign-posted.

The information required to make a management decision on recreation use relates to the demand and the ability of the resource to meet that demand. Information on the number of visitors, frequency of use, total demand in terms of visitor days per year and distribution of the demand between different sites throughout the year will provide the basis for ranking sites in order of priority for development.

This information can only be adequately gained from on-site interviews where the user is questioned at the site and during the recreation experience (Davidson, 1970 a and b; Countryside Commission 1972; and Countryside Recreation Research Advisory Group, 1973). Such questioning need not be verbal. Questionnaires can be made available at the site, but a lower response rate would be expected than with personal interviews. A standard questionnaire, however, has the advantage that many sites can be sampled simultaneously with little additional cost.

Information on the use of scenic drives and particular access routes is best obtained using vehicle axle counters. Some observation should also be made of the popularity of stops along routes and the duration of these stops. The collection of this information would aim to monitor the need for parking bays and picnic sites along heavily used routes. It would also provide information on popular routes should traffic need to be controlled during forest operations or fire or other emergencies.

The type of development required at various recreation sites is dictated to a large extent by the demands of particular activities and the features of the physical resource. What facilities the user sees as necessary for recreation use will depend primarily on the <u>user's</u> perception of the resource and recreation experience. Public attitudes about a resource's recreational potential can influence management, and individual perception of site carrying capacity may influence the type of development planned for a site. Sinden and Smith (1975) examined users' preferences for forest landscapes and found that exotic plantations provided greater opportunity for recreation use than indigenous forest for a specific inland northern NSW community. While this finding is not immediately applicable to the indigenous forests of the South Coast, it shows the importance of examining user preferences. It would be useful to know, for example, whether visitors to the South Coast forests preferred large, open grassed areas to cater for a substantial number of visitors or whether more smaller such areas would be preferred.

Site carrying capacity (the number of visitors able to use a site before conditions become too crowded for enjoyment) is also influenced both by the physical resource and perception of the recreation experience. A small beach, for example, will carry more visitors without their feeling crowded than the same area of grass alongside a river. Tall vegetation around the river-bank site and on the opposite bank will constrict the visual extent of the site. The carrying capacity of a site will depend also on the perception of the recreation experience. Visitors in control of young children, for example, may prefer an open space to ensure that children can be supervised with ease. They may also prefer to have other similar groups nearby. Smaller groups of a different age group may prefer privacy, and an area with properly spaced groups of trees will improve the sense of privacy even on the same area that would be considered crowded without trees.

This type of information; that is, the amount of use, type of use, characteristics of users and user preferences, provides part of the set of information required. Information on the resource, the physical features that facilitate recreation and the response of the resource to use is also important. This information could be based initially on the bio-physical survey undertaken for multiple use management zoning. The detailed data on vegetation types, hydrology and topography can be applied to recreation use in a number of ways. Firstly, the delineation of areas similar to currently used sites will enable future expansion of recreation opportunities and permit the planned development of one area in order to close a damaged recreation site. Secondly, a map of upper and lower canopy vegetation on the scale envisaged will permit the mapping of areas sensitive to recreation use. This will depend, however, on an understanding of the response of vegetation and soils to different forms of disturbance. Also, the identification of resistant forms of native vegetation (banksias, for example, appear to withstand soil compaction around their roots better than other species) will provide an additional management tool.

Information on these relationships between the resource and its use will also be required to determine, for example, the most fire-resistant species to plant around camp grounds, the most suitable native grasses or whether grasses should be introduced. A plethora of questions require to be answered, but information on these relationships cannot be obtained through a simple survey. Measurement of the parameters needed to make the management decision, therefore, should aim not only at gathering information through inventory, but also at building up an experience of the relationships between the resource and its different uses. Such relationships also exist between different uses such as the impact of wood production and recreation on wildlife and habitat values. This type of information is again long term in nature because it cannot be obtained through a single formal survey.

4.2.3 Conservation of flora and fauna

Information on flora and fauna conservation values is required at two levels. Firstly, to determine whether dominant use status should be given to particular wildlife or vegetation communities and, secondly, to determine areas where conservation values should constrain the dominant use, and determine minimum impact management practices for the dominant use.

Basic survey data represent the base-line for multiple use management. Such data provide information on diversity, distribution and abundance of plant and animal populations. In the case of vegetation communities such information could be provided by the bio-physical survey already mentioned. The occurrence and distribution of tree species is adequately documented but there is a need to extend this to cover understorey species which provide essential indicators of ecological diversity. In respect of fauna, only limited and very broad survey data are available for the spotted gum forests of the South Coast (Tidemann, 1978; and Nicol, 1978). Information on the abundance and distribution of wildlife needs to be gained from population surveys before any informed management decisions can be made.

The information required to determine whether a particular community deserves reservation, and therefore dominant use status, centres on the rarity of, or threat to, the community or species. Rarity is a measure of representativeness throughout a locality, region or country, and the security of a community is a measure of the stability under current land use. Information is thus required on the distribution and abundance of the community in the locality, and elsewhere, as well as on reservation status throughout its range.

In the case of the South Coast forests such information is not available, or incomplete at best. Currently a number of studies are being undertaken on plant and animal species but no communities requiring reservation have been identified as yet. It could be expected, however, that particular associations between individual tree and understorey species will be of sufficient interest to be considered for reservation, such as the infrequent but not uncommon occurrence of pure spotted gum in association with an understorey of <u>Macrozamia communis</u>. Also a number of tree and understorey species occur at the limit of their range and this may contribute to their value for reservation.

The fact that Murramarang National Park adjoins both Kioloa S.F. and Benandra S.F. will have a bearing on dominant use zonation for conservation purposes. As further information becomes available on the wildlife and vegetation species actually present in the park greater pressure could be placed on the State forest to provide protected habitats for species not reserved in the park. Alternatively the demand for conservation of habitat may be compatible with certain silvicultural practices thereby permitting the zonation of conservation use as a secondary use.

The information required to determine whether conservation values should be given secondary use status, and therefore constrain the dominant use to a certain extent, relates to the demand for conservation and the compatibility between uses. As implied above the measurement of demand for conservation centres on the representativeness and security of a community in terms of its range of occurrence. This not only requires basic information on the distribution and abundance of particular species but also requires an understanding of the relationship between the animal and its habitat or the plant and its environment. It is this latter understanding that is also required before a knowledge of the compatibility between various uses can be gained.

Some measure of the type and amount of disturbance that a population of plants or animals can sustain is essential to an understanding of compatibility between uses. An indication of the type of information required can be gained from recent wildlife studies. In general, most of these wildlife studies indicate a relatively wide environmental tolerance for ground dwelling mammals but a correspondingly narrow tolerance of environmental changes for arboreal species. This feature is reflected in the habitat requirements for the two species groups.

The small ground dwelling mammals, for example, require some form of ground cover. As well, the more dense vegetation types, such as the mesic shrub communities along creeks, support higher densities of these animal species than less dense forms of ground cover such as dry sclerophyll grassland (Suckling et a, 1976). Most forest types have sufficient ground cover to support even a sparse population of many of the common small ground dwelling species.

In contrast, some of the arboreal mammal species require a particular type of forest (that may not be as widely distributed as dense understorey), for example, old growth forest dominated by large over-mature trees with a high density of nesting holes and a certain amount of structural diversity. Some species, for example the yellow-bellied glider (Petaurus australis), prefer a habitat containing a secondary tree layer under the dominant tree canopy (D. Woodside pers. comm.).

Basic information on habitat relationships with avifuana is also lacking. Survey data have been collated for the South Coast area (Nix and Brooker, 1978). This survey showed the occurrence of some habitat specific bird species of limited distribution in the region. These species include the catbird and southern fig-bird, both of which occupy the southern limit of their rainforest habitat. Little is known of the impact of habitat modification on bird species in this area. The importance of this information on habitat modification and its impact on wildlife species of limited distribution is highlighted in the New Zealand example of the West Taupo State Forests, where all logging was stopped for three years pending the completion of a study on the North Island Kokako, an endemic bird species.

It is likely, however, that where endangered bird species are not involved, the maintenance of the present floristic and structural diversity of indigenous forests may provide sufficient opportunities for most bird species to survive in the area.

It is unlikely that the information required to make these management decisions will be available for some time. Basic survey data could be obtained from a formal population survey using established techniques of trapping, pellet counts, transect counting and so on. This, coupled with basic habitat data provided by the bio-physical survey, could establish habitat dependence and tolerance to changes in various forest structures and species components such as age of overstorey, occurrence of understorey species, and density of understorey. Long term, specialist wildlife studies would, however, need to be conducted to determine the impact of various management practices, especially wood production activities, on particular wildlife species. Such studies would need to measure as well aspects of species behaviour, including dietary range, fecundity and mobility.

4.2.4 Water and soil values

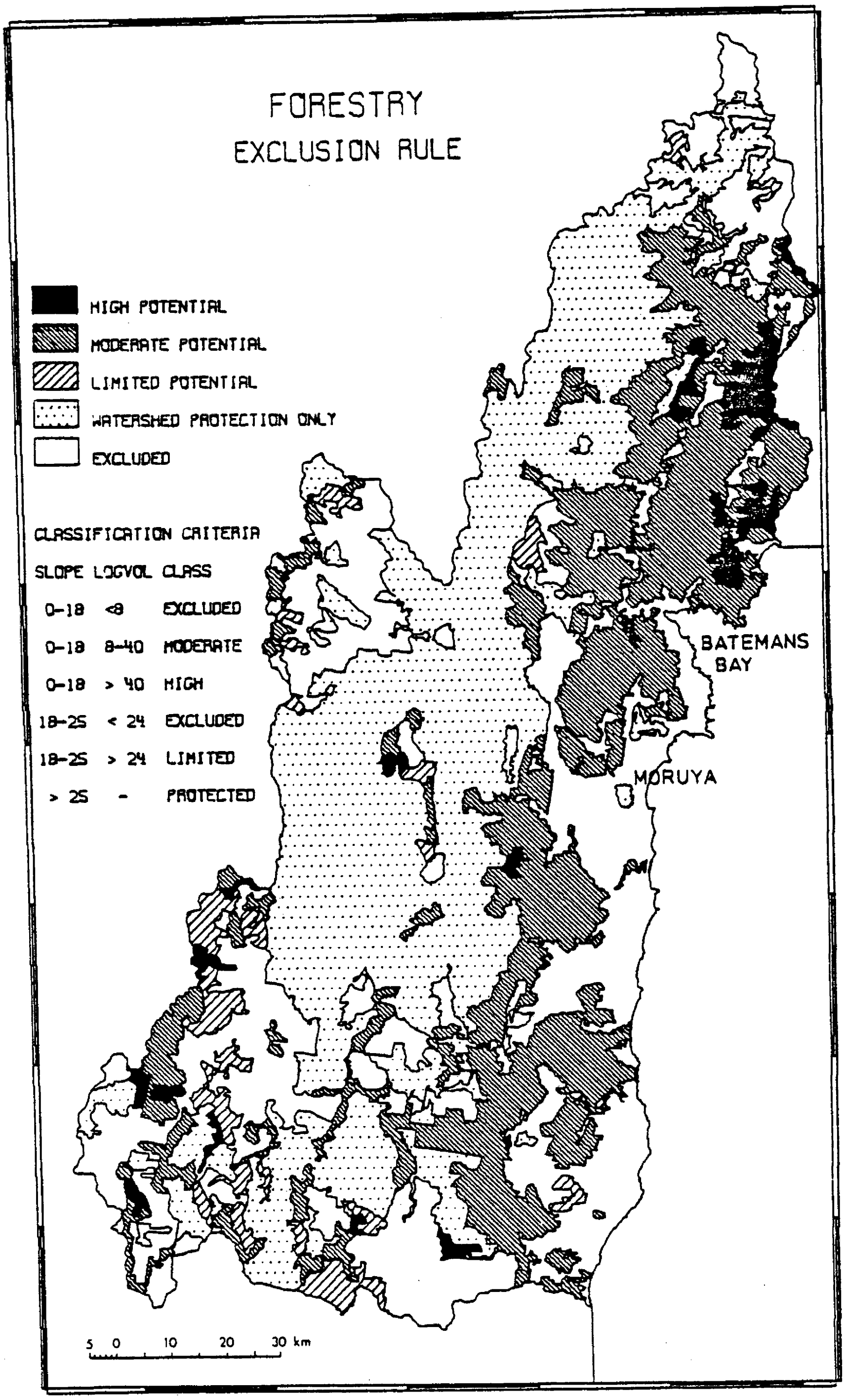
The demand for water and soil conservation is not normally expressed in quantitative terms such as litres per day water yield or millimetres per year topsoil erosion, but as a certain standard below which water and soil values should not drop. That level is set by local demands for water yield, water quality and flood control.

Only rarely is land zoned primarily for water and soil conservation, and then it is most frequently for the purposes of domestic water supply. The use of land for domestic water supply is normally governed by legislation which places responsibility for such land use (and the land itself) under separate authority. Land which is placed under the control of the Forestry Commission is subject to water and soil conservation normally only as a secondary use.

There are situations, however, where the constraints imposed by water and soil considerations may preclude the dominant use. Duggin and Saunders (1978), for example,

Figure 6

Forestry land use potential on the South Coast of NSW.*



*Source: C.S.I.R.O. (1978), p81.

have suggested that in the South Coast region wood production by any means should be excluded from slopes greater than 25° on sedimentary parent material (Ordovician and Permian) and on slopes greater than 20° on the "high-risk" granite. These areas constitute the western escarpment area of the South Coast region and do not impinge to any extent on the spotted gum forest types in the area. Figure 6 shows the area zoned for soil and water protection based on the application of the 'forestry exclusion rules' mentioned above (CSIRO, 1978). The topography and soils of the study area are such that water and soil values would rarely achieve dominant status, but would most often impinge as constraints on the dominant use.

Where soil and water values are generally secondary to wood production, operational techniques have been developed to minimise the impact of wood production activities. For example, the standard erosion mitigation conditions for logging and clearing in NSW impose certain restrictions on harvesting and roading in NSW State Forests. Apart from operational constraints, the only constraints on the silvicultural decision relate to activities near streams. Such restrictions are presented below as selected abstracts from the Report of the Senate Standing Committee on Science and the Environment (1977).

"2. Conditions for logging

...b) Filter strips

(i) A filter strip is defined as a strip of existing vegetation retained along both sides of a stream.

(ii) A filter strip of existing vegetation shall be retained to extend at least 20m on each side of a stream, and shall be provided downstream from the point on that stream where its catchment area exceeds (at most) 100ha. Both the width of the filter strip and the catchment area may be varied if, in the opinion of the Forestry Commission or Catchment Areas Protection Board, shape, soil erodibility or stream conditions so warrant, in which case width and area shall be specified.

c) Felling

(i) No tree shall be felled into a watercourse within a filter strip.

(ii) Trees may be felled into or within a filter strip. Tractors shall not enter the filter strip to remove logs.

(iii) No logging operations shall take place within 100 metres of the top water level of any major water storage.

(iv) No tree shall be felled within 20m of a prescribed stream as defined under the Water Act 1912 without specific authority.

(v) Logging operations should be carried out so that there is a minimum disturbance within any entrenched watercourse."

In regard to the South Coast forests the information required for silvicultural planning relates to the consideration of such prescriptions and their implementation in terms of the spotted gum forest types and topography.

Duggin and Saunders (1978), for example, have suggested that no more than 50% of merchantable volume be removed from slopes greater than 18°. This constraint would apply to minimal areas in Kioloa State Forest and Benardra State Forest where it would be limited to steep, moist gully sides. State forests west of the Princes Highway, however, would be affected to a greater extent and many open, dry slopes would be subject to this constraint. Such a constraint would impose considerable limits on the choice of silvicultural treatment available to produce timber.

Soil and water constraints could also be expected to apply to recreation where it is zoned for dominant use. The impact of recreation use could be controlled by the use of prescriptions applied to the development of recreation facilities. Controls on the size of car parks or on the distance between car parks and recreation sites can limit the number of visitors and thereby control the impact of use. Specifications on the provision and design of walking bridges and trails can reduce impact. The simple provision of a bridge, even across a normally dry creek, will concentrate pedestrian traffic on the structure and relieve trampling of creek-side vegetation or damage to the creek bank which could be aggravated at times of peak flow. The control of vehicular access is one of the most important factors in controlling erosion in this area. Where properly formed and maintained roads are not provided, and visitors make their own tracks, gullying and other forms of erosion can rapidly degrade an area.

4.2.5 Landscape and aesthetic values

The maintenance of landscape values in State forests becomes an important issue where indigenous or exotic forests provide a backdrop viewed by large numbers of people such as forests in sight of cities, views from lookouts, vistas behind lakes, and visual corridors along roads. The spotted gum forests of the South Coast provide impressive visual corridors along the Princes Highway and the many minor roads in the area. Like the blackbutt forests of northern coastal NSW, the form and unusual bark of spotted gum add to the beauty of the vista seen from the road.

There are few high points in the area and many of the scenic vistas afforded from the highway are westward, the Murramarang Range to the east blocks clear views of the coastline from the highway. A notable exception is Ingold's Knob Lookout which lies three kilometres south of the Termeil Store and one kilometre west of the Princes Highway. The lookout provides attractive views of the coast and the coastal forests east of the highway. The Murramarang Range runs parallel and close to the coast, often less than a kilometre from the shoreline. Various high points along the range afford views of the coastline. Points such as Pine Knob and Lovell's Pass rise to 120 metres, Don Moir Hill rises to 160 metres, and Durrass Mountain, the highest point on the range, rises to 283 metres. Durrass Mountain lies within Murramarang National Park and views eastward look across the narrow strip of park toward the sea. The views from these high points toward the west are not as critical because they look across approximately 20 kilometres of indigenous forest on broken country towards the western escarpment.

The Batemans Bay-Braidwood road, crossing the Clyde River at Nelligen, also traverses State forest and visual corridors associated with this road are equally as sensitive as the Princes Highway. The former is a popular route for tourists from Canberra, many of whom own holiday houses on the coast between Batemans Bay and Ulladulla. Permanent settlements occur in the area at Termeil, East Lynne, Benandra, Bawley Point, Merry Beach, Durrass and Long Beach. Areas of forest that can be seen from these settlements will be subject to certain constraints imposed by landscape values.

The demand for conservation of landscape and aesthetic values is difficult to measure. Often the only yardstick the resource manager has is the extent of public reaction and comment against a management decision that has already been implemented. The factors affecting this demand are inter-related to certain other aspects of forest use and the resource itself. The demand is closely related to other forest uses, in particular recreation. For many, a view of the forest is encountered during vacation periods. During such times the visual character of the forest environment forms an integral part of the recreation experience. For others who live in the area certain changes to the forest brought about by logging may decrease their appreciation of their own locality.

Another, and by no means insignificant, benefit derived from the forest landscape is the latent benefit arising from a knowledge that the resource is being conserved and the potential to use it in the future exists. Many who have little intention of actually using the resource themselves would derive benefit from the knowledge that the resource is there for others, including future generations, to use.

Information on the relationships between demand and the physical features of the forest creating that demand is more easily obtained. There is a demonstrable relationship between vegetation type and visual quality. Spotted gum, for example, would generally be considered to have a higher visual character than *Eucalyptus piperita* in the South Coast forests. Forest structure also relates to visual quality. For instance, a tall stand with long clear boled trees may be considered more aesthetic than a low stand with short, forked boles, especially in a coastal forest environment. The presence of a dense understorey may also detract from the impression of height of individual trees in a stand lowering the overall visual quality of the forest. In other circumstances, however, a dense understorey could be useful as a screen behind a certain width of visual corridor along roads.

The presence of a particular forest structure may detract from landscape values. Lookout points, for example, are particularly sensitive to nearby vegetation and the management decision would need to balance a number of demands occurring in such a conflict. Often views are enhanced by clearing all vegetation from a vantage point, but sometimes similar views can be achieved by removing understorey at the highest point, secondary canopy trees further down the slope, and then only a few upper canopy trees, if any, need be removed from the lower slopes. This technique limits the scene from the point of view of photography, but retains a protective and generally complete forest structure over the site.

This information on demand in terms of the physical resource could be obtained at the same time as the recreation survey simply by including certain questions relating to specific sites, where personal interviews are carried out, or by adding general questions relating to scenic points of interest where questionnaires are used.

In the South Coast spotted gum forests landscape values are likely to be secondary to most other uses and are almost entirely compatible with uses other than wood production. A number of techniques have been developed for landscape conservation in wood production areas (Lennon and Forge, 1975; Speight, 1976, 1977 a and b; USDA, 1973; and Weir and Smith, 1974). These techniques involve the mapping of sensitive areas such as zones along roads, and areas seen from vantage points located both within and outside State forests. Following this mapping exercise various constraints are imposed on silviculture carried out in these sensitive areas in order to minimise the impact on landscape values.

The information required to determine the extent and type of constraints imposed on wood production to conserve landscape values relates firstly to a knowledge of the relationships between the demand and the physical characteristics of the forest, and secondly to an understanding of the way the forest can be manipulated through silviculture to meet these demands. While clearfelling, for example, may be precluded because of landscape values, selection logging methods may be suitable, permitting wood production to continue as the dominant use.

Where selection logging or other logging methods which remove only part of the forest canopy are carried out, the immediate visual impact can be reduced by minimising disturbance to the understorey. Where clearfelling is undertaken as a regular silvicultural treatment or harvesting method, it is generally excluded from very sensitive landscape areas. Where it is undertaken, the timing of the operation in relation to the height of surrounding stands and the shape and size of the clearfelled area, can be controlled to minimise visual impact.

The impact of constraints imposed on wood production due to landscape values is not likely to be significant in the South Coast forests. Few large areas would be totally excluded from wood production solely on the basis of landscape considerations mainly because the most widely applied harvesting method, that of selection logging, is generally compatible with conserving the forest landscape. There will be some areas, specifically narrow visual corridors, where disturbance could be detrimental and logging may need to be restricted to salvage of dead or dangerously broken trees, especially in the vicinity of recreation sites. These corridors would normally be between 20 and 40 metres wide. The impact on wood production, if these areas were excluded from logging, would be limited to a total area of approximately 20 hectares. This area represents the sum of areas of corridors 20 metres wide along major scenic roads through the forests between Batemans Bay and Ulladulla.

4.3 Inter-relationships between uses

Up to this point each use of the forest, and the information required to make management decisions on those uses, has been treated separately. When the full set of uses, and information required on each, are amalgamated a complex system of interactions between demand, resource use, and the physical resource emerges. Only a few of these interactions will be mentioned here in order to highlight the need to consider the management decision in its broadest context; that of balancing a complex physical system (the forest ecosystem) with an equally complex set of human demands on the resource.

Changes in the forest structure brought about by logging or silvicultural treatment are important to other uses, and the extent of these changes can have differing effects on these uses. The most common result of silviculture, whether timber is extracted or not, is a reduction in the density of the forest canopy. Sawlog harvesting operations generally remove a portion of the dominant canopy layer whereas non-commercial thinning or extraction of small-wood products (posts, poles, sleepers and mining timber) normally removes a portion of the sub-dominant or suppressed canopy. Regardless of the type of treatment, the most common result is an increase in the light intensity on the forest floor. The extent and duration of this increase depends on the type of treatment with clearfelling having the greatest effect and release cutting the least.

One effect of this increase in light intensity is the development of the shrub and herb understorey. This can have marked effects on other forest values and uses depending on the type of vegetation involved. In the moist gullies and mid slope stands of spotted gum forest types on the South Coast a dense shrub understorey will often develop following logging. This shrub understorey increases the wildlife habitat available for small mammals including rodents, marsupial mice, bandicoots, wallabies and possums. The development of a dense shrub understorey can reduce the value of the stand for recreation by reducing the ease of access through the stand. The development of this shrub layer will, however, help to screen the impact of logging from view.

Another example of inter-relationships between demand, use and the physical resource can be seen in the provision of reserved strips of forest. Such reserved strips are provided in response to the demand for conservation of both water and soil values and the aesthetic values of the forest. In making this provision, certain useful physical features are preserved for other users. The use of filter strips, for example, to maintain water quality, preserves the vegetation along gullies and creeks. This will provide long term stability of wildlife habitat which should ensure a stable wildlife population within these habitat types. Also, the provision of visual corridors in response to the demand for scenery associated with car-based recreation also ensures the retention of relatively undisturbed vegetation. These corridors would provide for the conservation of a greater range of vegetation than in the case of filter strips. The retention of trees, within the visual corridors, for longer than the normal sawlog rotation period would increase the proportion of senescent trees which provide abundant habitat for arboreal wildlife.

The development of recreation sites along scenic drives will be facilitated by zoning for visual corridors. The use of visual corridors as zones for the development of recreation sites has limitations though, due to the fact that cleared areas could compromise the integrity of the corridor. Thus recreation site development may need to be covered by prescriptions which preserve as much of the existing vegetation as possible and provide a site with only limited facilities which discourage lengthy stopovers at the site. Camping and barbeque facilities would be inappropriate due to the inevitable impact of these activities on surrounding vegetation, and this impact could rarely be sustained in narrow visual corridors.

4.4 Inventory

The increasing complexity of management decision making requires an expanded inventory providing information on more of the physical and biological characteristics of the resource (Metcalf, 1974). Bamping (1974) has noted that the need for a more detailed inventory has arisen due to a number of factors. These include an increase in timber demand, decrease in land base, increased demand on forest land for alternative uses, and an increase in the intensity of management to optimise production. All these factors can be seen to be relevant in the South Coast forests.

Not all the information required to make fully informed management decisions can be obtained through a simple inventory of resources. Some information can only be gained through long term studies of the complex relationships between the components of the forest ecosystem and the influence of different forms of use on the forest. The first step in gathering the required information depends on providing resource data through a broad-based bio-physical survey. Due to the detail required for management decisions the techniques needed to survey the South Coast forests will differ from those used in the Canadian bio-physical land classification system mentioned in Chapter 2. The basic principles of ecological classification, based on patterns of relief, geology, geomorphology, vegetation and climatic effects would, however, remain applicable. Instead of using satellite photography, large scale colour aerial photography will be more useful. The use of computer-based techniques for information storage and processing, and the production of maps by this method would appear to have application especially for soil, understorey and tree classification surveys. Most of the information would be gathered by sampling. The intensity and design of sampling would vary depending on the parameters being measured. Following collection and analysis of this bio-physical information it would need to be initially presented as a series of maps similar to those produced by the CSIRO South Coast Land Use Study (Austin and Cocks, 1978). The scale of mapping should be between 1:5000 and 1:2500 to be useful for management purposes.

Following this a complete set of inventory plots would need to be established to provide both the long term information required on the response of the forest to different treatments and information specific to the different forms of use. Information on silvicultural treatment has been, and continues to be, collected both through periodic management plots and through special research plots. This technique needs to be extended to cover the full range of uses to be contemplated for the forest.

The parameters that may be involved in plot measurements include those related to the classification of the growing stock (crown quality, size class distribution, species present, bole height and merchantable volume); those related to the ecological classification of floristics and animal habitat (relative species proportions, overstorey/understorey associations, vegetation density, stand structure and understorey structure); and those related to the requirements for environmental planning (areas of likely logging difficulty, visually sensitive areas, water quality, soil and slope stability, recreation sites, scenic or other attractive areas).

The measurement of these parameters within a broad-based long term inventory framework should aim not only at gathering information, but also at building up an experience of the relationships between the several parameters and their influence on forest management. In this manner a broad appreciation of ecosystem processes and inter-relationships can be built up through the use of integrated inventory.

The design of an inventory to meet these needs will not be considered here other than to discuss some of the constraints likely to limit the information collected, and to examine ways in which some information can be estimated without being measured in every instance.

4.5 Constraints on information collection

It will not be possible to collect the full set of information outlined above due to the costs and time associated with its collection. The major constraint will, in effect, be the time constraint because many of the information requirements of multiple use management are of such a long term nature that the information may not be available before the management decision has to be made. It is for this reason that a policy of non-commitment is often followed thus leaving future options open. This approach, however, has declining relevance in the current climate of increasing demands for a full range of benefits from forest use. This option could be applied to the South Coat forests for a period of 30 years until the sawlog deficit is alleviated. The resulting forest condition, however, would generally not permit the continued extraction of timber at current levels due to a depletion of growing stock in the larger size classes.

The approach that is required to achieve the potential improvement in productivity, and thus indigenous timber output, as well as meeting the demands for other forest uses, is a commitment to future long term multiple use management. This commitment will involve (in the short term) zoning of the forest on the basis of an intensive bio-physical survey. In the longer term, the management technique to be applied within various zones can be determined using experience gained through inventory plots and research as already outlined.

The costs of an expanded and intensified inventory will, obviously, be greater than the costs of current inventory procedures. Carron (1974) suggests that the collection and processing of the additional information provided by a broad-based inventory could take the total cost of forest management beyond the revenue gained from wood production. This is compounded by the fact that, due to the condition of growing stock, increased production from many eucalypt forests cannot be achieved without substantial increases in investment (Florence and Shepherd, 1975). The increased management costs (including those of inventory) associated with increased forest productivity and provision of other forest benefits should be considered an additional public cost.

The extent to which such public costs are permitted to exceed revenue from wood production is a political matter. Nevertheless expenditure on all aspects of forest management will be limited and inventory will be constrained as much by costs as by time. For this reason not all the information required to make the management decision will be collected and a compromise will be necessary to determine the most efficient inventory methods.

Efficiency in inventory can be achieved through a number of ways. Firstly, the number of inventories can be minimised. The bio-physical survey and the system of long term inventory plots is seen here as the minimum needed to provide essential information. Secondly the number and size of sample areas or plots can be optimised. This can be achieved through various methods, the best being to estimate the inherent variation in the parameter being measured, which requires some knowledge of the resource prior to design of the inventory. A pilot survey is thus recommended to provide this information, as well as to determine the extent to which the third method of increasing inventory efficiency can be achieved. This third method is to minimise the number of parameters measured within each sample area. This can be achieved by determining relationships between various parameters. The specific measurement of numbers of nesting sites for arboreal wildlife could be replaced by an estimate based on parameters measured for tree production such as crown quality class and diameter which estimate the age and crown characteristics of the tree and could be used to predict the likely density of nesting sites. Alternatively, a certain proportion of bio-physical survey sample areas could be used to measure the relationship between habitat type, aspect, and wildlife population densities, thus providing an estimate of population over all sampled areas.

The integration of various parameters to provide estimates of other parameters can be extended to cover a wide field of information. Combining various measurements in this way will, however, limit the accuracy of the survey and this compromise will need to be accepted if basic information is to be obtained quickly and economically.

In the light of these constraints then the bio-physical survey could be expected to take the form of a single series of sample areas in which all the parameters being sampled are measured in every area. This departs from the ideal of a separate series of samples for each parameter of interest. It would also necessitate a compromise between the optimal size, number and placement of sample areas for each parameter. The design of the long term inventory using permanent plots would be similarly constrained by time and cost factors. As well there will be less opportunity to take advantage of integration of measurements due to the specialized nature of the long term inventory. The measurement of parameters such as water flow or water quality, for example, are restricted to particular sites amenable to that treatment, whether it be silvicultural treatment for wood production or treatment for recreation development or any other form of treatment. The efficiency of the long term inventory could be enhanced by maintaining an improved compartment record system which recorded various treatments carried out in the course of regular management. While quantitative measurements would not normally be taken prior to, or following, treatment within a compartment, a qualitative estimate of the impact of treatment and response of the forest can be useful if the type of treatment is recorded. As many of the treatments applied to the South Coast forests were carried out over the last 50 or 60 years, it would have been helpful to compare those treatments with current forest condition to determine their effectiveness. Whereas a fully documented compartment record system could not replace a permanent plot inventory, where quantitative measurements are taken over a period of time, it could help reduce the number of plots required and thus improve the efficiency of the inventory.

CHAPTER V

SILVICULTURAL IMPLICATIONS

The New South Wales South Coast forests have been discussed in terms of their use for multiple benefits, the factors affecting the silvicultural decision, and the information required to make the management decision. Finally, then, these need to be drawn together to examine the impact of multiple use management on the approach to silviculture in the spotted gum dominated forests. The following discussion aims at examining the silvicultural approach to the management of these forests for certain stated objectives, to identify the silvicultural implications of constraints imposed by other uses, and to highlight attitudes to forestry needed to successfully manage these public forests.

5.1 Implications of Objectives of Management

The proposed objectives of management have been outlined in the previous chapter (Section 4.1). Two major implications can be drawn from these objectives in terms of their effect on long term management.

Firstly, the production of indigenous timber from the South Coast forests is to be continued in the long term, on a sustainable basis, due to their easy topography and accessibility. A corollary to this is that a greater proportion of expenditure on State forests will be undertaken in these forests than on the escarpment forests to the west which will be managed primarily for periodic yield. Silviculture in the South Coast forests will, therefore, need to aim at providing a balanced size class distribution over a number of forests to ensure continuity of supply of wood products.

Secondly, the requirement to cater for recreation as an alternative use implies that multiple use management will be necessary. As has been argued previously, this may involve zonation of the forest to give precedence to other forest values. As a result restrictions will be placed on the production of timber from certain parts of the forest. Hence those areas where wood production can be carried out without restraint will need to produce more usable wood and silvicultural techniques will need to be developed to increase productivity on all areas where wood production is zoned as primary use.

While the intensity of management of these forests must be increased in order to improve productivity, the assumption that intensive management practices necessarily involve 'plantation or similarly intensive culture' should be seen as a narrow interpretation. The following section discusses ways of increasing the intensity of management without necessarily increasing the level of impact of silviculture on the stand.

5.2 Silvicultural management

The silviculture of the South Coast spotted gum forests can be considered in terms of three identifiable phases in the continuing management of the irregular forest. These inter-related phases involve establishment, growth and yield control.

5.2.1 Establishment

The characteristics of natural reproduction and the early responses of seedlings of species making up a community will largely determine the growing stock condition and productivity patterns within the unmodified stand. Therefore, where natural regeneration is the method of stand re-establishment, these characteristics must be understood.

The natural establishment and initial development of mixed species stands resulting in the seven forest types within the 'spotted gum league' (Baur, 1965), or the thirteen different vegetation communities containing spotted gum described by Austin and Sheaffe (1976) are not well understood. Turnbull and Pryor (1978), however, have summarised some establishment features of silvicultural importance for a number of economically important species. They highlight the importance of the seedling habit of blackbutt and the lignotuber habit of spotted gum, two of the most economically important species in the South Coast. As well, spotted gum flowers heavily, but infrequently, whereas blackbutt is characterised by large variations in the periodicity and pattern of flowering between individuals and seasons.

Thus the natural regeneration of spotted gum and blackbutt components of mixed stands depends, in part, on the extent of the lignotuber pool for spotted gum and the conditions for germination and seedling establishment for blackbutt.

However, the wide variation in ecological types within the spotted gum forests suggests a very much more complex pattern of stand reproduction. Therefore, the silvicultural approach to irregular forest management should recognise differences in individual species reproduction in the mixed stand, and in order to improve productivity, attempt to maintain an adequate distribution of spotted gum lignotuberous advance growth, with periodic establishment of non-lignotuberous seedlng regeneration on the better blackbutt sites. This need not necessarily involve clearfelling coupes of a substantial size. It could, for example, be achieved on some sites by harvesting to retain high quality pole size blackbutt as seed trees, ensuring site conditions are appropriate for the establishment of blackbutt seedlings, but at the same time conserving as much of the lignotuberous advance growth as possible. In this instance, while conditions remain favourable for establishment of the blackbutt seedlings, spotted gum and other lignotuberous species may respond rapidly to release. However, because of the narrow individual crowns of spotted gum and the early vigour of blackbutt seedlings, the blackbutt seedling regeneration may rapidly join the lignotuberous growth in the advancing sub-canopy.

Other sites which may not be as suited to blackbutt, but may favour other species, such as E. saligna in the moist gullies or E. piperita on lower fertility sites, will require a knowledge of the individual species' regeneration requirements on those sites before silvicultural treatment can successfully ensure controlled establishment of the desired irregular forest with improved productivity.

Beyond this establishment phase competition rapidly sets in, and growth characteristics of species and stand components become important in determining initial stand structure and subsequent growth rates.

5.2.2 Growth

There are two inter-related aspects of growth important to silviculture. These are individual tree growth and growth under competition within the stand.

Some individual tree growth characteristics of species of the spotted gum forests have been summarised by Turnbull and Pryor (1978). They note the resistance of spotted gum (within its natural range) to stress such as fire, moderate droughts, pests and diseases. The species is characterised as being highly tolerant to Phytophthora cinnamomi, but tolerant of only light frosts. The species-site adaptations have also been noted. Spotted gum grows best, even to the extent of pure stands, on moist, well drained soils of moderately heavy texture. On the South Coast such soils are found on shales, slates and granites, but not sandstone (Turnbull and Pryor, 1978).

The growth characteristics of blackbutt contrast with those of spotted gum in some ways. Blackbutt is much less resistant to fire, drought and disease than is spotted gum. Blackbutt grows on sites of low nutrient status but requires well aerated soils, growing poorly on soils of restricted root or moisture penetrability. The species is characterised by a deep taproot with a carrot-like swelling at the base of the stem which may function as a lignotuber in the early stages of seedling development. Blackbutt is also susceptible to browsing by native animals. It is also very susceptible to Phytophthora and other root fungi.

A knowledge of these growth characteristics may give some insight into observed ecological pattern. It may also provide some understanding of growth of species within the stand. While individual species' habits play a part in stand growth, some of the differences in growth rates of trees within the stand can be explained both by the present position of the trees in the stand and an interpretation of their silvicultural history. Thus the present crown position, the physiological age of the tree, and the intensity and duration of past competitive influences all play a role in understanding the current and potential growth of trees in an irregular mixed species forest.

Keady (1978) combined these factors into a crown classification in order to predict the growth of individual trees constituting various components of the stand. While he did not attempt to suggest optimum growing stock levels of the irregular spotted gum forest, or to explain the dynamics of spotted gum stands, his work has laid the foundation for answering these questions. A number of important conclusions may be drawn from his work, some of which have already been used as examples in this essay.

In the context of silvicultural planning, probably one of the most important features of Keady's analysis is that, on sites he sampled, mature dominant spotted gum had lower increment rates than mature dominant trees of other species. Thus the choice of spotted gum as the principal sawlog species may result in some loss of potential sawlog yield. However, if other species were chosen for sites at present dominated by spotted gum, this potential gain must be balanced against the potential loss of yield if the induced replacement species were not well suited to the site. For example, a silvicultural treatment to favour blackbutt may not improve productivity on all sites, especially where rooting depth may be limiting. This line of argument may also be followed in regard to the occurrence of the stringybark species in association with spotted gum (namely, *Eucalyptus agglomerata*, *E. globoidea* and *E. muellerana*). These species may be silviculturally favoured on suitable sites for specific product requirements. Their apparent early rapid growth may be capitalised on to produce some of the smaller size products including poles, sleepers and mining timber. This highlights the need for further research to establish more clearly the relationships between individual species and specific sites.

Another important feature shown was the very limited response in diameter growth of spotted gum to change in stand basal area, compared with blackbutt. This relationship was only examined for other than dominant trees (see Crown Quality Classes 6 - 12, Table 7). This may be interpreted as requiring different stocking rates for different species mixes in the stand. For example, where vigorous pole and advance growth stems of blackbutt occur intermingled with a high density of spotted gum in similar sizes, it may be advantageous to reduce the stocking of spotted gum on the site. Conversely, an apparently high stocking of spotted gum advance growth may not significantly affect the growth rates of individual trees. Another significant result that quantified a logically expected result was the magnitude of the difference in growth rates between stand components. Keady's analysis highlights the extreme effects on productivity of past competitive influences as interpreted by the use of the crown quality classification. These results should significantly influence present attitudes to forest productivity in irregular forest management.

A direct result of such complex models describing tree growth is the increased complexity of the management approach. Keady (1978) has suggested that any silvicultural approach aimed at reducing this complexity would certainly facilitate the management of these forests. However, if the forester wishes to maintain the irregular structure and quasi-natural species patterns, this simplification cannot reasonably be entertained. The approach to silviculture under these circumstances must be to recognise the uniqueness and complexity of each stand and, based on an understanding of this complexity, to select equally unique silvicultural treatments for productive stands.

The phase of producing wood under this flexible silvicultural approach will now be discussed.

5.2.3 Yield control

A limited number of studies have addressed the problem of production and control of growing stock in irregular forests. A logging schedule in irregular spotted gum forest was developed in Queensland (Florence et al.,1970), and a similar approach was recommended for blackbutt (Florence and Phillis, 1971). In both cases the continuity of supply was considered critical to the management of the forests.

In the spotted gum example (Florence et al.,loc. cit.), silvicultural management had previously been based on strict application of a cutting girth limit in logging. Under the recommended new schedule, log removals would be made through all merchantable size classes, with follow-up treatment to remove poor quality or inhibiting unmerchantable stock. The logging prescription specified standards of retention for both logging of merchantable classes and the subsequent improvement treatment. The effect of logging on the stand largely depended on the condition of the existing growing stock, and logging resulted in markedly different final stand structures on the three plots examined. In one case, where an overmature stand was logged in the prescribed manner, only 37.3 stems per hectare remained after logging. In view of other constraints which may be applicable under multiple use management, this result may be undesirable.

Furrer (1971) has examined the application of three logging schedules to spotted gum forest on Kioloa S.F. The aim was to compare the schedules in terms of growth rates and quality of the resulting stand. The treated forest was a high density overmature stand with a high volume of unmerchantable trees. The three schedules were:

1. Clearfelling
2. Quality stem retention (QSR)
3. Maximum retention of merchantable growing stock (MRMGS).

A summary of the different schedules and their results will now follow.

Schedule 1 - clearfelling

"All useful material was harvested including sawlogs and mining timber. Poles were infrequent and did not allow commercial removal, so were sold as mining timber. The complete area is now available for regeneration and treatment ... after yielding approximately 42 m^3 (13,727 sup. ft. H.) merchantable volume" (Furrer, 1971).

After nine years regeneration is becoming prevalent. The photograph below shows this regeneration ranging from two to four metres in height and consisting mostly of spotted gum.

Plate E

Clearfelled plot after 9 years, Kioloa S.F.

Schedule 2 - quality stem retention.

The prescription aimed to retain those trees with vigorous crowns and straight defect free boles. Minimum bole length criteria imposed were as follows:

(i) trees greater than 71.1 cm (28") dbhob - a 9.1 m (30') merchantable log length,

(ii) trees 50 cm (20") to 71.1 cm dbhob - a 10.7 m (35') merchantable log length,

(iii) trees less than 50 cm dbhob - the potential to reach a 12.2 m (40') merchantable log length.

The plot now appears as in the photograph below. The irregular canopy shows the extent of removal of dominant trees. In fact 76 stems per hectare (31 s.p.a.) were retained.

Plate F

Plot treated under schedule 2 (QSR), Kioloa S.F.

Schedule 3 - maximum retention of merchantable growing stock.

> "A schedule designed to maintain the greatest level possible in usable growing stock after the application of a cutting girth limit. The chosen cutting girth limit was 71.1 cm (28") dbhob. All trees above 71.1 cm were felled as well as trees below this limit whose condition indicated the tree would be unlikely to survive a further twenty years. This was indicated by crowns where dieback and distortion showed clearly". (Furrer, 1971).

This last plot retains some of the original stand structure as shown in the photograph below. Some emergent crowns indicate the position of the dominant canopy in the stand.

Plate G

Plot treated under schedule 3 (MRMGS),
Kioloa S.F.

Data analysed by Furrer (1971) indicate that growing stock retained by the MRMGS schedule was better able to capitalise on release over the very short increment period he measured (2 years), than the QSR treated stand. He observed that almost full site occupancy was retained by growing stock in the MRMGS plot. It must, therefore, be assumed that regeneration was not markedly stimulated.

The rigid silvicultural specifications applied by Furrer may provide useful data in the future, but as a standard silvicultural approach, such prescriptions may be inappropriate. The work of Keady (1978) implies that the response of trees to different levels of release from direct competition varies with the interpreted vigour of the individual tree. The interpreted vigour is itself related to physiological age and health, and position in the canopy, as well as interpreted growth history and species characteristics. Therefore, a more flexible approach to a logging schedule with individual tree marking by personnel familiar with these growth characteristics could be expected to yield better results in terms of wood production in the irregular stand.

Furrer also makes the point that for the impact of silvicultural treatment to be acceptable for other forest values a series of consecutive treatments may be necessary. For example, in the MRMGS treatment the initial operation might involve the removal of the merchantable trees marked for felling. Subsequently, a follow-up operation some months (even up to a year or two) later could involve the further removal of trees below the cutting girth limit marked for non-commercial felling.

Another factor given limited consideration by Furrer was the continuity of product supply through all size classes. Obviously the clearfelled area will not contribute further to product supply in the short term. Also, the application of the QSR schedule in practice has left a stand of only limited ability to yield sawlogs in the next ten to thirty years.

5.3 Implications of constraints on management

5.3.1 Timber supply

The objective of maintaining supply of wood products in the long term, and the need to meet the current level of supply commitments in the short term (especially in relation to sawlogs), restricts the flexibility with which silvicultural techniques can be applied to the forest. This will limit the immediate potential to improve productivity by requiring that nearly all advance growth, whether moribund or young growth, should be retained if it is capable of producing a sawlog in the next 30 years. Thus stands containing young regeneration, which is suppressed by an overstorey remaining after previous logging, will remain suppressed until the overstorey is removed.

This short term constraint must not be permitted to eclipse the long term aim of improving productivity. The tendency to neglect stands containing few stems which could produce a sawlog in the next 30 years should be resisted. In fact the sooner such stands are treated to promote recruitment of regeneration or to enhance growth rates of advanced growing stock, the sooner will the potential increase in productivity be realised. Also most of the treatment applied to such stands would involve non-commercial operations and as such are likely to be given a lower priority than operations yeilding revenue. Again the only justification for expenditure on non-commercial treatment lies in the contribution of such treatment to increased overall productivity in terms of quality sawlog output from the forest.

5.3.2 Recreation demand

The stated objective of providing suitable forest areas to meet recreation demand will have major implications for silvicultural treatment other than simply reducing the amount of wood immediately available for extraction. In areas where wood production is zoned as a secondary use to recreation special techniques will need to be applied so that timber can be extracted while minimising the impact on recreation.

Areas where recreation use is concentrated and heavy for only a part of the year, such as camping grounds away from beaches, will permit a certain amount of low intensity wood extraction during the "off-season". However, the use of the site during brief holiday peak periods is likely to cause damage to existing growing stock and may also prevent any regeneration becoming established. Such effects are likely to arise from trampling, clearing for tent sites, the movement of vehicles or firewood collecting activities. It will be difficult to ameliorate the effects on regeneration while the site is being repeatedly used. Rotation of camping sites of this nature is often necessary. An alternative could be the physical protection of numbers of small trees chosen to replace older trees likely to be removed in the future using devices such as steel drums or wire netting.

The impact of recreation demand on silviculture can be even more direct when the problem of firewood (where the demand for fuel wood causes depredation of the nearby forest) is considered. Of the two approaches to this problem, that is, banning wood fires or providing fuel wood, the latter is the most commonly preferred solution except during periods of fire danger. The supply of fuel wood can provide an outlet for otherwise non-useable stems arising from harvesting operations throughout the forest. The economics of collecting and distributing this wood, however, will probably favour the establishment of a fuel wood crop close to the recreation site. This would impose a direct constraint on the silvicultural decision by imposing a single-product regime on the stand.

Lower intensity recreation demands such as walking trails, picnic sites and so on involve similar implications for silviculture. Areas close to human activity will be subject to substantial disturbance which may inhibit regeneration or damage growing stock. The maintenance of a relatively intact forest canopy, in order to provide shade, will limit the range of silvicultural treatments that can be applied in such reaction areas. Single tree selection will probably be the most appropriate harvesting method in recreation areas restricted to specific sites, whereas broader-scale uneven aged management could be carried out over most other areas.

5.3.3. Conservation of other forest values

The stated objective of maintaining species distribution implies that the regeneration requirements of individual species are known and that such conditions can be provided in the managed forest. Of course this knowledge is not available for the full range of species (even just tree species) occurring on the South Coast and the silvicultural implications of the objective are not clear. It is not stated, for example, whether artificial planting of indigenous species is to be permitted and, if so, whether maintenance of relatively pure local genetic resources will be an important aim in any areas zoned for vegetation conservation. While the objective of maintaining present species distributions will assist vegetation conservation values generally, the specific limitations on silviculture arising from this objective have yet to be clarified.

The potential to increase productivity could also be limited by the objective of maintaining species distribution if it is interpreted too narrowly. The NSW Forestry Commission (1976) notes that scope for manipulation of species proportions exists while meeting the above objective. There will, however, be some difficulty in attempting to achieve both things at once. That is, to provide appropriate conditions for the regeneration of particular species while at the same time ensuring that the proportion of a highly desirable commercial species increases. Little knowledge of the ecological requirements of the various tree species on the South Coast is available as yet to determine the possibility of achieving these two aims simultaneously through silviculture. They could well be incompatible and further compromise between wood production and conservation values may be necessary.

Areas where wood production is carried out subject to the constraints of wildlife conservation will require special silvicultural consideration in regard to the remaining forest structure and the size and shape of the treated area.

It has been noted previously that different forest structures provide habitat for different wildlife species. The occurrence of senescent trees in filter stands and visual corridors may be sufficient to support populations of arboreal species. However, additional old growth forest may be required, to ensure survival of viable populations of particular species in the region. Because the removal of senescent trees will be restricted, the stand may only yield a crop of small trees grown under a dominant overstorey. In this situation silviculture aimed at producing special smallwood products such as posts and battens may be justified.

The size and shape of individual treatment blocks, and the habitat resulting from treatment has significant implications for wildlife (McCann, 1975; and Cremer, 1969). Large circular areas, for example, provide a lower circumference to area ratio than smaller elongated areas. Thus migration of wildlife species into treated areas will be enhanced in small treatment blocks with a large edge between treated and untreated areas. Clear-felling operations that drastically reduce wildlife numbers should therefore be carried out in long narrow coupes that encourage their rapid recolonisation. Other less dramatic treatments would be less sensitive to treatment shape.

Apart from the impact on vegetation values, the size of the treatment area also affects the rate of movement of wildlife species into the area. Thus if wildlife values are to be maintained the size of the block should be kept to a minimum consistent with the aims of silvicultural treatment of the stand.

The constraints imposed by soil and water values have major silvicultural implications. In filter strips, for example, few trees could be extracted due to the limitations of tractor access. Minimal silvicultural treatment would be applied in these strips other than soil stabilisation by revegetation where necessary. The suggested constraint of less than 50% merchantable volume removed from slopes of 18° would directly limit the range of silvicultural treatments that could be applied to such slopes. In effect treatment would be limited to manipulation of species proportions within a selection logging regime. The recruitment of regeneration may prove difficult under such circumstances.

5.3.4 Costs associated with management

The ability of a forest authority to implement multiple use management will be severely constrained by available funds. The inevitable increase in expenditure required can only be justified in terms of the increased benefits arising from a wider range of forest uses.

The imposition of constraints on silvicultural and harvesting operations will increase the financial costs of wood production. Opie and Thompson (1977) have examined the impact of adding successive environmental constraints to a clearfall logging regime. Substantial cost increases resulted from constraints on regenerative treatment whereas consumer price of the final product was affected only marginally.

This situation arises because of the cost-plus nature of most wood pricing. Where wood is sold on this market residual basis additional revenue cannot be generated by increasing the price of the wood at stump. Therefore, unless stumpage increases are achieved on the basis of the true costs associated with growing wood additional revenue from general taxation will be required. It could be argued that, as with increases in other social benefits, additional revenue should be supplied by the general taxpayer (Thompson, 1970). While this may be so, substantial increases in available funds are unlikely to be rapidly forthcoming. Any additional funding is likely to be used in developing recreation sites and maintaining improved roads for public access. Thus silvicultural management will probably continue on a minimum expenditure basis with harvesting operations having the highest priority.

With increases in the demand for output in the full range of forest benefits, including timber, and limited additional funding with which to achieve this, the forest manager is faced with a complex management decision. This decision will involve an attitude to multiple use management characterised by flexibility in the approach to silviculture. No single set of management prescriptions will meet the multiple use objectives of the forests in the South Coast region. A wide variety of silvicultural treatments will need to be applied with varying intensity and under varying constraints. No two stands will be similar in their full set of constraints on management and their required output of wood products, recreation benefits or conservation values.

CHAPTER VI

CONCLUSION

The silvicultural approach needed to manage the irregular mixed species eucalypt forests of the New South Wales South Coast is characterised by flexibility.

The silvicultural decision needs to reflect a sensitivity on the part of the forester to the various needs of management. The forester also needs to be aware of the complex nature of the pattern of variation and various ecological relationships unique to the particular forest area.

As the aims of management become broader, taking into account the multiple benefits available from the use of the forest, so do the requirements for information become broader and the whole management process becomes more complex. This development in the information required to make the silvicultural decision should be met by new attitudes to information collection and thus inventory.

The forest manager must, therefore, face new challenges in management involving not only a wider appreciation of the nature of the resource, but also a greater commitment to deeper consideration of the impact of management decisions.

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